

Research Report 1399

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Development, Implementation, and Evaluation of a Maintenance Performance System

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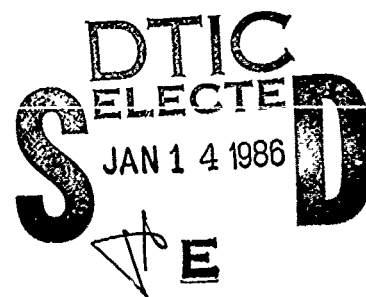


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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report describes a three-year project to develop, implement and evaluate an Army Maintenance Performance System (MPS(O)) for organizational level maintenance in armor and mechanized infantry battalions. From specific maintenance and training information provided by the MPS(O), managers, super- visors and trainers can assess and solve problems of resource allocation, skill deficiencies, and equipment readiness. The MPS(O) automatically main- tains a task-performed inventory for each mechanic and indicates need for training on low-skill tasks. (Continued)		

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20. (Continued)

A prototype MPS(O) developed early in the project was later modified to Division-86 maintenance needs and a refined version was operated by contractor staff on-site at Fort Carson, CO. The final version was operated by Army personnel at Fort Carson in three test battalions during an evaluation period.

Maintenance leaders in MPS(O) battalions assessed key elements of their maintenance work related to effectiveness more positively than did maintenance leaders in a control non-MPS(O) battalion. Maintenance information needs were found to be satisfied better the longer the MPS(O) was used.

A separate evaluation of the MPS(O) conducted by one of the test battalions revealed that: mechanics increased shopwork hours from an average of 4 to an average of 17 hours per week; crew members increased preventive maintenance hours from 4 to 10 per week, on the average; task qualifications and certifications of mechanics increased; newly assigned mechanics reached satisfactory skill levels in 30-90 days with MPS(O)-based structured training; the frequency with which maintenance tasks had to be repeated on the same vehicles decreased; and the equipment serviceability rate improved.

An armor battalion with the MPS(O), which participated in battle training at the National Training Center (NTC), was commended for its combat service support and maintenance by NTC evaluators.

Investigations concluded that the MPS(O) would operate in the U.S. Army Europe environment and that it was compatible with other ongoing developments of logistics and maintenance systems.

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Research Report 1399

Development, Implementation, and Evaluation of a Maintenance Performance System

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FOREWORD

The Army Research Institute has been conducting research on improving techniques for the management and delivery of technical training for maintenance personnel in the unit environment.

This research was stimulated by the continuing difficulties that operational units experience in developing, retaining and managing sufficient numbers of trained mechanics. This document is the final report of a three-year effort. The objective was to develop, implement, and evaluate a maintenance performance system designed to enhance performance on Army maintenance jobs at the organizational level in armor and mechanized infantry battalions. From the specific maintenance-related measures provided by the system, managers and supervisors can assess maintenance productivity and efficiency and relate them to personnel skill and performance. Skill deficiencies can be identified and corrected by unit-level training. Provision is made for record-keeping on task qualification and the award of certificates to qualified personnel. The completed system, including supporting documentation, was developed and handed over for operation by Army personnel.



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Technical Director

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We wish to acknowledge the help of U.S. Army Forces Command in providing troop support throughout the life of the project at Fort Carson, CO, and during a data collection visit to Fort Stewart, GA. The Commanding General of the 4th Infantry Division (Mechanized) at Fort Carson, CO, assigned two armor and one mechanized infantry battalion to help test the completed system. The armor battalions' personnel provided operational guidance and suggestions during the developmental phases of the work. We are most grateful for their help.

The Army Ordnance Center and School and the U.S. Army Training Board acted in an advisory capacity to ensure key training factors were included in the system. We appreciate greatly the help given by the representatives from those agencies in supplying needed documents and participating in reviews.

DEVELOPMENT, IMPLEMENTATION AND EVALUATION OF A MAINTENANCE PERFORMANCE SYSTEM

EXECUTIVE SUMMARY

Requirement:

To develop, implement, and evaluate a system that will enhance Army maintenance at the organizational level; to incorporate within a Maintenance Performance System (Organizational) (MPS(O)) methods for diagnosing maintenance performance and training problems, and for prescribing appropriate solutions at the unit level and within unit resources; and to design the MPS(O) to be operable by Army personnel with minimal training.

Approach:

- Collected and analyzed reference information on current operator and organizational maintenance practice in armor and mechanized infantry battalions.
- Identified frequent and critical maintenance tasks performed by organizational mechanics and crews for track, wheel, turret, and communications equipment.
- Analyzed key tasks for each selected MOS, and equipment item as a basis for defining essential maintenance performance and training skills.
- Developed an information subsystem for unit maintenance and training information with data storage and processing functions embodied in a small computer.
- Conducted supporting research for the MPS(O): developed an institutional curriculum for motor sergeant's training; determined the relationship between task performance frequency and maintenance proficiency; developed techniques and guidelines for unit on-the-job training (OJT); and developed motivational elements for the MPS(O) action-taking component.
- Prepared supporting documentation for the MPS(O): system description, operator manuals, training and certification guides, users' interpretation guides for performance measures, and special reports on supporting research issues.
- Studied the potential of MPS(O) for operation in geographically dispersed operations at National Training Center (NTC), Fort Irwin and United States Army in Europe (USAREUR).

- Investigated compatibility of MPS(O) with ongoing developments in other Army maintenance systems such as Standard Army Maintenance Systems (SAMS) and the Unit-Level Logistics System (ULLS).
- Implemented the MPS(O) in two armor battalions and one mechanized infantry battalion from the Fourth Infantry Division (Mechanized) Fort Carson, Colorado (4th ID (Mech.)).
- Evaluated the MPS(O) by analyzing objective and subjective data collected during the final year of the project.

Findings:

The project objective was met by producing the MPS(O) that was handed over and operated by Army personnel. The final MPS(O) encompassed eight maintenance Military Occupational Specialties (MOS) and the equipment of an armor/mechanized infantry battalion. The system was proven capable of operation by Army personnel during operations in two armor battalions and a mechanized infantry battalion of the 4th ID (Mech) at Fort Carson, Colorado.

Analyses showed that the MPS(O) does not duplicate maintenance information from existing or developing Army systems such as Standard Army Maintenance System (SAMS), Maintenance Activity Management System (MAMS) used in V Corps in USAREUR, and the Battalion Maintenance Management System (BMMS) of the Army Training Board (ATB). The performance, skill, and training information collected and analyzed by MPS(O) is unique.

The MPS(O) will operate satisfactorily in geographically dispersed locations such as those characterized by USAREUR operations, provided that the collection of maintenance data is assigned the same importance as other maintenance-related activities.

Detailed analyses of maintenance performance measures and user information examined during the last year of the project supported the underlying premise governing MPS(O) development: that efforts directed toward increasing maintenance management skills and enhancing mechanics' performance skills were considered by maintenance personnel in the armor (test) battalions as an important contribution to improvements in maintenance effectiveness.

Maintenance leaders in MPS(O) battalions assessed key elements of their maintenance work related to effectiveness more positively than did maintenance leaders in a non-MPS(O) battalion. Maintenance information needs were found to be satisfied better the longer the MPS(O) was used.

A separate evaluation of the effect of MPS(O) was conducted by the battalion in which the development and formative testing was conducted. This provided an assessment of MPS(O) effectiveness over the longest time period (18-24 months). The battalion experienced the following improvements over this period:

- Mechanics increased shopwork hours from an average of 4 to 17 hours per week.
- Crew members increased preventive maintenance hours from 4 to 10 hours per week.
- Newly assigned mechanics reached satisfactory skill levels in 30-90 days using MPS(O) structured training.
- The frequency of repeated maintenance tasks declined.
- Equipment serviceability rate increased.

While these changes occurred in a dynamic environment in which MPS(O) was only one of the operative variables, the battalion maintenance managers concluded that MPS(O) had contributed significantly to these improvements. Additionally, it is important to note that it is not feasible to track continuously all but the last of these measures without a system like MPS(O).

Conclusions:

- MPS(O) provides unique and timely information to unit maintenance managers that aids in the systematic development of technical skills and in identifying underlying causes of unit maintenance problems.
- MPS(O) increases maintenance awareness at all levels within the line battalions.
- MPS(O) can be operated without undue burden by unit personnel provided that normal institutional supports are in place, such as manuals, job aids, and training packages.
- The high rate of personnel turbulence within the battalions participating in this research greatly limited their capability to build and maintain an adequate base of technical maintenance skills.

Recommendations:

- MPS(O) should not be implemented as a separate system requiring its own minicomputer, but rather should be folded into the operation of other planned Army computer-based maintenance or logistic systems.
- That MPS(O) be considered for incorporation in an emerging computer-based processing and information system being designed for the battalion level and below.

DEVELOPMENT, IMPLEMENTATION AND EVALUATION OF A
MAINTENANCE PERFORMANCE SYSTEM

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INTRODUCTION

Much concern has been directed toward improving maintenance management and maintenance training for those supervisors and soldiers who maintain today's inventory of Army weapon systems. The need for a structured and organized approach to improvement of maintenance at the organizational level has evolved from numerous surveys, observations, and measures of organizational maintenance that have pinpointed specific performance problems. An important problem is that maintenance leaders do not always have adequate, timely information upon which to base decisions. Even when information is available, it is often in such form as to make analysis difficult. Problems of maintenance and the training of maintenance personnel have been further increased by the complexity, sophistication, and diversity of the systems to be maintained.

Because of budgetary constraints, the Army has responded to the challenge of providing adequate training by requiring it to be conducted by operational personnel in the unit. This contrasts with the previous concept of training maintenance personnel in specialized schools. The objective of unit-level training is to provide what training is needed, where it is needed, when it is needed. However, unit-level training also increases the responsibilities of unit-level maintenance managers and supervisors who must not only diagnose maintenance performance, but must also identify training needs and develop and administer appropriate training.

The current project was initiated to help maintenance managers and supervisors diagnose training needs, prescribe and execute training solutions, enhance motivation of maintenance mechanics, and have access to maintenance information to support management decisions. The resulting system provides information hitherto unavailable and provides this information in a form to facilitate decision-making that responds to the pressures, needs, and objectives of the operational mission. Developing and implementing a maintenance performance system within the limits of available resources required answers to questions such as:

- What maintenance information is needed and by whom?
- How can information be collected, analyzed, and distributed in an efficient manner and impose a minimum burden on the unit?
- In what form should information be presented?
- How can maintenance information be used to enhance motivation?
- How can information on skill be related to maintenance effectiveness?
- What should the role of the Battalion Motor Officer (BMO), Battalion Maintenance Technician (BMT), and Motor Sergeants be in a maintenance performance system?
- How can mechanics' skills and qualifications be measured and recorded?
- How can maintenance quality be measured and recorded objectively and easily?

Initial project investigations revealed the scope, variety, and amount of specific performance problems. From work done in the early stages of this project, maintenance performance problems were categorized into five problem areas-- command emphasis, management information, management proficiency, application of resources, and technical proficiency. **Command emphasis** is the importance given to maintenance by Army leaders and the reinforcement of maintenance importance by the supportive actions that leaders take. Command emphasis is shown at the bottom of Figure 1 as the foundation and ultimate driving force for obtaining effective Army maintenance. Higher elements in the diagram depend upon and are supported by those below. **Management information** is required for effective planning and decision-making. In addition to information on maintenance status, scheduling and performance, it includes information on personnel capabilities and development. **Management proficiency** consists of the ability of maintenance leaders to plan, decide, develop, organize, and motivate when applying maintenance resources. **Application of resources** includes the methods for communicating, assigning tasks, and developing technical skills. **Technical proficiency** is the combination of skill and motivation that leads to the successful accomplishment of maintenance tasks, and characterized as **maintenance effectiveness**.

During development of the MPS(O) all five elements were considered. Furthermore, because these elements interact, they combine to provide a framework for increasing maintenance effectiveness.

Though not shown in Figure 1, information feedback is essential for successful maintenance activity. For example, feedback on maintenance effectiveness, technical proficiency, and application of resources is needed to maintain up-to-date management information. Also, direct feedback on maintenance effectiveness is needed to sustain both technical proficiency and command emphasis. Thus, the figure illustrates the importance and central role played by information collection, analysis, and dissemination. This concept provided a framework for developing the MPS(O).

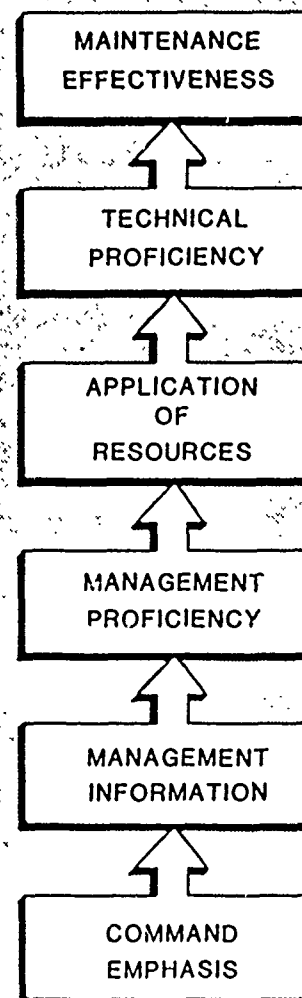


Figure 1. Elements in maintenance effectiveness.

OBJECTIVES

The overall objective of the three-year project as defined in the original Statement of Work (SOW), was to develop and evaluate a maintenance performance system at the operator and organizational level. The system was to facilitate the diagnosis of maintenance performance problems and, where appropriate, prescribe specific training solutions within the constraints of unit resources. The end product was to be a "turn-key" system that would encompass a spectrum of equipment items and MOSs in an armored and/or mechanized infantry battalion. The product was also to be capable of Army-wide application, probably as part of a larger system.

Several supporting objectives were also discussed in the SOW. The role, responsibilities, and ultimate training of the Motor Sergeant (considered to be the driving force behind effective unit maintenance) were to be defined. To help in developing measures of maintenance skill levels, the relationship between frequency of task performance and skill level of maintenance mechanics was to be investigated. To support the development of on-the-job training methods, applicable techniques were to be explored and assessed. And to assure that the resulting system would promote the motivation of mechanics, maintenance incentive and motivational factors were investigated.

An interim objective was to develop a prototype system based on maintenance needs and procedures for an armor battalion. By working closely with an operational unit, practical problems in field application would be identified. Accomplishment of this objective was originally conceived for an armor battalion in a conventional armor or mechanized infantry division; however, the impending impact of the Division-86 (DIV 86) reorganization in the early stages of the work required the preliminary system to be modified to match the reorganization. The following tasks governed the development of the maintenance performance system:

- Obtain information on operator and organizational maintenance practice and doctrine which could influence the design of a maintenance performance system.
- Develop a data collection system that will provide the needed information input for system operation.
- Develop appropriate algorithms and methods for computer-aiding to assist in management and processing of maintenance data.
- Develop and format a simple, easily understood method of presenting output information for both maintenance management and training needs.
- Document the development and provide appropriate reference material for system users.
- Implement the prototype system in an armor battalion for initial shakedown and assessment.

- Modify the system based on user feedback; assure system compatibility with ongoing Army doctrine.
- Develop appropriate and comprehensive documentation to meet the requirements for a self-contained system, i.e., operator and user manuals, training guides, and performance interpretation guides.
- Prepare the final system for operation by Army personnel.
- Develop a training course and train unit personnel in system operations.
- Assess, within available operating constraints, the effect of the system on unit maintenance performance.

PROJECT GUIDELINES

The MPS(O) development followed a general pattern of initial investigation of organizational maintenance performance issues and conduct of supporting research during the first year, with further development and modification of the MPS(O) during the second year. Implementation, refinement, and preparation for Army operation and use of the final MPS(O) took place during the final year of the project. Assessment of MPS(O) utility also took place during the final year of the project. The MPS(O) was designed to provide information for action by Army maintenance managers and trainers responsible for solving maintenance performance problems, for overcoming deficiencies in technical skills, and for maintaining the unit's maintenance effectiveness at a high level.

The MPS(O) was developed in accordance with guidelines established initially by the Statement of Work and subsequently modified, during working meetings with representatives of the sponsoring agencies and participating parties, as the work progressed. The following guidelines were used:

- An armor battalion (identified hereafter as Battalion 1), volunteered as the unit which would provide technical guidance on field operations and permit testing of the prototype MPS(O) under field conditions. This assistance was to be provided on a not-to-interfere basis. Subsequently, another armor battalion (Battalion 2) and a mechanized infantry battalion (Battalion 3) also participated in system operation and testing.
- Data reduction and dissemination of results were to be the responsibility of Anacapa Sciences staff during the development and testing stages of the MPS(O). Off-site data reduction and batch processing were to be used during initial stages of development of the prototype system. When the final operational version of the MPS(O) was developed, on-site processing was to be used.
- Anacapa Sciences was to be responsible for training system operators and for conducting on-site training for designated personnel from the MPS(O) units.
- After handover to the user battalions, Anacapa Sciences was to remain on-site in an advisory capacity until unit operators were adequately practiced in system operation.
- Appropriate system documentation oriented to users' needs was to be developed. This documentation would accompany the operational version of the MPS(O) when handed over for Army operation.
- The IBM 5120 computer programs and procedures were to become the property of the Army under the terms of the contract.
- Anacapa Sciences was to ensure that the computer program was adequately documented from a system point-of-view so programmers from other agencies could understand and modify the system later if required.

- The system was to be designed to be compatible with use under field (simulated battle) conditions and in accordance with the combat environment foreseen for United States Army in Europe (USAREUR) operations.
- The MPS(O) was to be designed to be capable of operating in Army units other than Armor or Mech Infantry battalions. This would involve incorporating degrees of flexibility to permit changes of equipment and changes to participating MOS's and the tasks they performed.

MPS(O) DEVELOPMENT

TECHNICAL APPROACH

The approach to development of the MPS(O) involved two major tracks. One dealt with the core of the MPS(O)--the **Management Information System** component. The other dealt with **supporting research** leading to development of the other MPS(O) components, i.e., Training, Certification and Action-taking. The relationships of these to subsequent steps in the approach is shown in Figure 2. Each box in the figure is described below. The shaded boxes represent the four major components of the MPS(O).

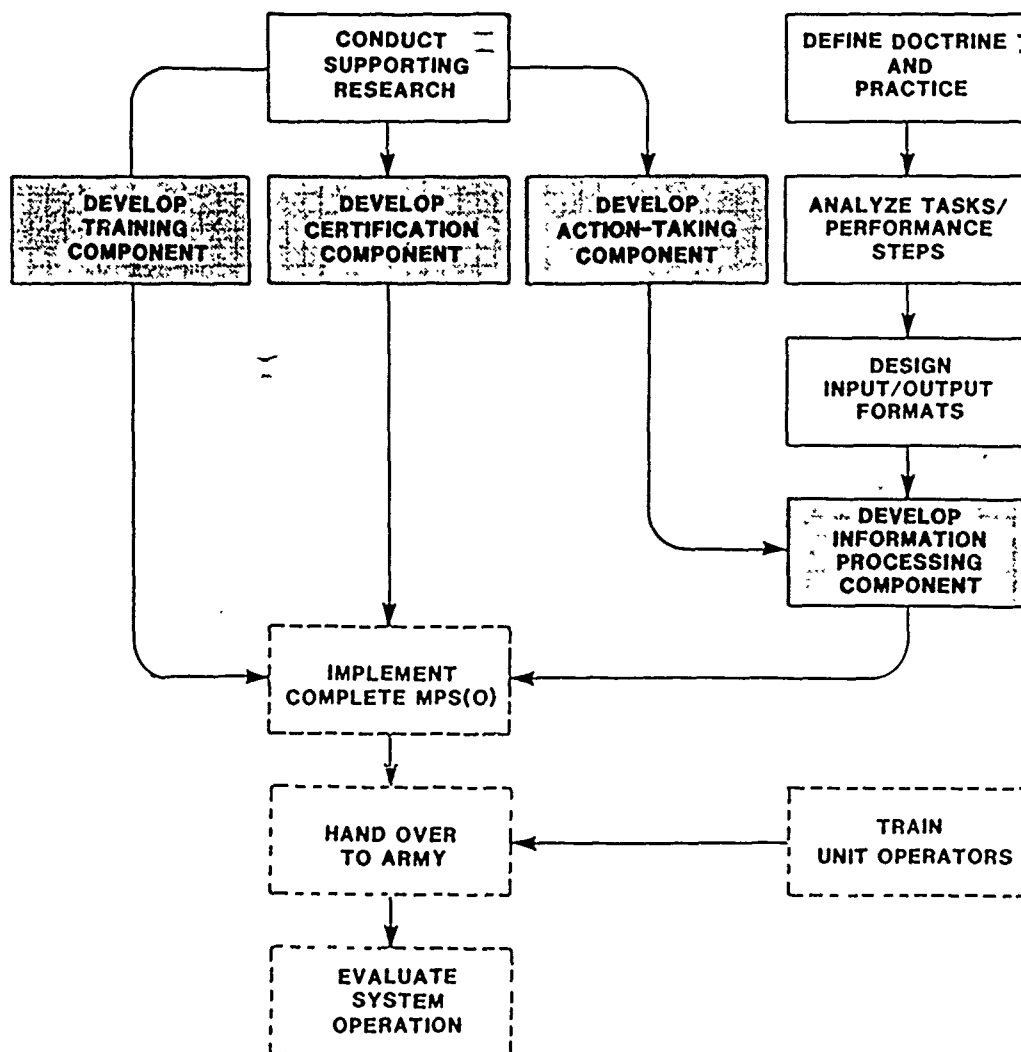


Figure 2. Key steps in MPS(O) development.

The boxes in the figure that specifically relate to the developmental phase of the project are:

- **Define Doctrine and Practice:** Maintenance doctrine, practice, and derivation of one from the other were defined. The results reflected the actual conditions which governed ongoing development of the MPS(O).
- **Analyze Tasks/Performance Steps:** Tasks were analyzed down to the performance step level for equipment maintained by maintenance MOSs in track, wheels, turret and communication technical areas.
- **Design Input/Output Formats:** A system specification was written to guide development of the algorithms used for input, processing, retrieval, and formatting for the output reports.
- **Develop Training Component:** Research was conducted to develop an appropriate curriculum for training motor sergeants; for developing OJT guidelines; and for structuring technical training under control of the BMO.
- **Develop Information Processing Component:** The algorithms were programmed for minicomputer operation.
- **Develop Certification Component:** Research resulted in a method for recognition of mechanics' proficiency via provision of a certification component in the MPS(O). Structure, level, criteria and awards were defined for the certification component.
- **Develop Action-Taking Component:** Different levels of action-taking were identified. A major outcome of motivation research conducted separately was to include the mechanics in formal action meetings based on output data from the information system, and reinforce involvement via participation and provision of feedback.

Note that the boxes in Figure 2 bounded by interrupted lines are discussed later under headings related to Implementation and Evaluation.

MPS(O) development is described in more detail in subsequent paragraphs. Related work is also described concerning the relationship between technical skills and maintenance effectiveness, for assuring that the MPS(O) would not be redundant with existing maintenance systems, and in examining the potential for MPS(O) operation in dispersed conditions similar to those existing in USAREUR. The complete technical program is provided in the first project interim report (Harris, 1981).

MANAGEMENT INFORMATION COMPONENT

Define Doctrine and Practice

At the outset of the project it was important to summarize current practice with respect to each aspect of operator and organizational maintenance. These practices were identified and defined from interviews conducted in four armor battalions. The results provided a comparative data base. A technical report (Fuller, Rugge, & Harris, 1981) provided narrative and graphic descriptions of current practice in addition to:

- Detailed descriptions of significant variations of practice from doctrine.
- Comments obtained from those individuals who could provide insights into maintenance practice and performance.
- An annotated listing of unit-specific regulations and directives that related to maintenance practice.
- Copies of maintenance forms that were actually used during operator and organizational maintenance.

The objective of this analysis was to gain information for building a practical system that reflected real-life conditions rather than designing to "what should be." Field units often have to make on-site adaptations to doctrine and practice to meet special conditions that were not considered when the doctrinal documents were originally developed. The information obtained from this initial investigation was also useful in providing guidelines when MPS(O) compatibility with other Army systems was examined.

Analyze MOS Tasks and Performance Steps

An inferred objective was to provide full coverage of **all** maintenance MOS's and the work they did on associated equipment in an armor battalion. But investigation of candidate MOSs for inclusion showed that some MOSs did not do the same work as that defined for their specialty, or they did it but only in simulated combat environments and never in garrison. These men were usually employed in areas other than those pertaining to their primary MOS.

Men such as these would not be able to provide the quantity or quality of performance needed by the MPS(O), hence they were not included. The general criteria governing inclusion of an MOS in the MPS(O) were that the MOS holders must actually be working on-site in a maintenance capacity on appropriate equipment for his primary or assigned duty position, and have an expectation of high frequency of repair performance. Performing a job once, say every six months, would not be acceptable for inclusion under the MOS acceptance criteria (Harper, Rugge, & Dyck, 1981).

By applying appropriate criteria, the specific personnel identified for the MPS(O) by MOS were:

- Drivers/Crews of M60A1 Tanks, AVLBs, and M113-FOV, MOS 11C, 19D, and 19E, (included as a group only, not as individual crewmen). (Note: MOS 12F (Engineer tracked vehicle operator) was originally included but later dropped as a result of MOS 63 career field re-organization. MOS 63N assumed the MOS 12F duties.)
- Tactical Communications Systems Operator/Mechanic, MOS 31V.
- M60A1/A3 Tank Turret Mechanic, MOS 45N.
- Fighting Vehicle Systems Turret Mechanic, MOS 45T.
- Light-Wheeled Vehicle Mechanic, MOS 63B.

- Heavy-Wheeled Vehicle Mechanic, MOS 63S.
- M60A1/A3 Tank System Mechanic, MOS 63N.
- Fighting Vehicle System Mechanic, MOS 63T.

The specific equipment covered in the MPS(O) is listed in Table 1. Variations in the equipment were sometimes misleading. For example, although the M60A1 tank and the AVLB appear to be (and are) vastly different vehicles they use the same chassis. Automotive maintenance is therefore the same for both vehicles.

TABLE 1
SPECIFIC EQUIPMENT COVERED IN MPS(O)

TRACKED VEHICLES:

- M60A1-Series Tank
 - M9, Dozer Tank
- M60A1L-AVLB
- M113A1-FOV Armored Personnel Carriers
 - M106A1, 107mm Mortar Carrier
 - M125A1, 81mm Mortar Carrier
 - M132A1, Flame Thrower Carrier
 - M577A1, Command Post Carrier
 - M901, ITV, TOW Carrier
- M88A1-Medium Recovery Vehicle
- M578-Light Recovery Vehicle

WHEELED VEHICLES:

- M151- $\frac{1}{2}$ Ton Truck
- M35-FOV $2\frac{1}{2}$ Ton Trucks
- M54-FOV 5 Ton Trucks
- Gama Goat Family
 - M561, $1\frac{1}{2}$ Ton Cargo
 - M792, $1\frac{1}{2}$ Ton Ambulance
- GOER-FOV
 - M520, 8 Ton Cargo
 - M553, 10 Ton Wrecker
 - M559, Fuel Tanker
 - M877, 8 Ton Cargo with Crane

COMMUNICATIONS EQUIPMENT:

- Radios
 - AN/VRC-12, Radio Set and components
 - AN/VRC 43 through 49, Radio Set, and components
 - AN/VRC 64, Radio Set, and components
 - Other Communication Equipment
 - CVC Helmet
 - SB-22 and SB-993 Switchboards
 - TA-1 and TA-312 Telephones
 - KY-57 Communications Security
-

We used several sources to identify appropriate and critical maintenance tasks. No one source was adequate by itself. The sources included Soldier's Manuals (SM), technical manuals (TM), specialists from proponent schools and subject-matter experts. The final unit-approved task lists were derived from a composite of all these sources. SM-defined tasks are written for the general audience of an Army-wide MOS. Some equipment listed in the SM was **not** issued to the units we covered. In other instances, the equipment the units **did** have was not listed in the SM.

Technical manuals were also examined to identify appropriate tasks for selected equipment. But the TM's were sometimes out-of-date, sometimes unavailable. The task descriptions in the TM's were sometimes at variance with unit-developed maintenance procedures used in the field.

The proponent schools contributed to the final task list development by identifying the critical tasks for each equipment item. The subject-matter experts (SME) (usually senior warrant officers and maintenance sergeants) helped to bridge the gap between doctrinal information and the "tried-and-true" tasks unit personnel actually performed in garrison and field environments (Harper & Rugge, 1981).

Key performance steps necessary to complete a repair task are technically not required for MPS(O) operation. However, they are almost mandatory for definition of what is included/measured during performance of a task. We had previously noted during previous work on a Direct Support maintenance project, that users experienced major difficulties in deciding exactly what task statements encompassed. We found that the detailed key performance steps developed in that project reduced semantic confusion by defining precisely what steps a task included. We noted in the previous DS work and also in the MPS(O) work reported here that unfortunately, key performance step descriptors in SM's often differed in detail and scope from those contained in TMs, or even as understood by maintenance personnel on the shop floor. For example, some maintenance tasks require that a major component which prevents access to a faulty part be removed, although the major component itself does not require repair. Some TM's and SM's include such removals as part of the repair task sequence. Others interpret the repair task literally and assume the faulty part is already on the workbench. Removal of the preliminary component is not, in some instances, considered as part of the repair task.

The sets of performance steps we identified in this phase of MPS(O) development were reviewed, revised and finally approved by maintenance specialists and SME's from field units.

Design Input/Output Formats

The Input/Output Formats included development of simple ways to collect and record maintenance events and present summaries in easily understood formats. The MPS(O) reports provided information related to MOSs and maintenance performance in four technical categories:

- Track vehicle automotive repairs
- Wheeled vehicle automotive repairs
- Combat vehicle turret and armament repairs
- Communications equipment repairs

Algorithms were designed which governed development of a minicomputer program to handle the large amounts of data. This is described in more detail in the next section.

The MPS(O) reports were designed to reflect the need for brevity, simplicity, and ease of interpretation. The recipients of the reports included only those persons with maintenance responsibilities. They were:

- Battalion Commander
- Battalion Executive Officer
- Battalion Motor Officer
- Battalion Maintenance Technician
- Battalion Motor Sergeants
- Company Commanders
- Company Motor Officers (Company Executive officers)
- Company Motor Sergeants
- Individual Mechanics

The reports were distributed on the basis of a criterion of whether the recipient had authority, knowledge, and capability to take action. "Nice-to-know" and general interest were not considered an adequate criterion for receipt of the reports. The intent of limited distribution was to avoid providing each person who had some maintenance-related interest with all reports and giving him the choice of abstracting those close to his personal interests. Recipients, of course, could request information reports that they wanted but did not receive. The Battalion Commander, for example, received only a single page summary report every four weeks illustrating the status of training overall and task performance, and the status of vehicle repairs overall for each company. This provided him with the "big picture" on maintenance performance and training in succinct terms.

The MPS(O) was designed to produce reports in ten categories. In addition to a roster, and a set of interpretation comments, **Maintenance management** reports were developed for use in gauging maintenance efficiency, effectiveness and personnel availability. These were generated at four-weekly intervals for distribution to commanders, maintenance managers, and senior supervisors. **Training information** reports were developed to reflect experience, qualifications and certifications for each individual mechanic and for each MOS as a group. These reports were generated every six weeks and distributed to training personnel and training management. Each individual mechanic was provided with his personal skill profile listing the equipments he had worked on since his introduction to the MPS(O), the tasks he had performed on each equipment, the number of times he had performed the tasks and his skill level related to other mechanics in the MOS. The Roster referred to above was used in the MPS(O) to track individual soldiers within their MOS's. Since one of the major advantages of the system was that it kept track of soldier's performance on a task-by-

task and vehicle-by-vehicle basis, it was important to maintain a listing of mechanic arrivals and departures. The roster fulfilled this need.

The **Interpretation Comments** were used to highlight events that could influence interpretation of the quality and quantity of data in the reports. For example, the interpretation comments include dated notes on the mission training status of the unit and any events such as "Iron Horse" week where the whole division concentrated on physical fitness. A detailed discussion of each output report with examples of its format is contained in the user's reference manual (see Fuller, Wotkyns, & Spiker, 1983).

Develop Information Processing Component

The algorithms that related to input/output formatting were used as the basis for development of a complex program to be run on a minicomputer located in each user unit.

The primary purpose of the information system was to provide processed information in summary report form that described ongoing maintenance and training operations on demand. The system also provided the important function of recording and storing information on personnel and equipment. Thus a newly-assigned supervisor could have immediate access to accurate maintenance management and training information that previously resulted only from lengthy experience on the job. Job information was stored accurately and in timely fashion in the computer for each individual mechanic--something the manually-completed job book has been unable to provide because of the demands on the NCOs who are responsible for its completion. The specification for the MPS(O) program to process these data was developed to encompass data input, storage, file manipulation, data base editing, and report printing. Since the anticipated system operators were eventually to be Army enlisted personnel with no specialized background, the specification required that the program display extensive prompts and error messages, with suggestions for their solution and even a capability of automatic error-checking of operator inputs for range, type, and in some cases, compatibility with prior inputs.

CONDUCT SUPPORTING RESEARCH

The research tasks described below formed the second track of MPS(O) development depicted on Figure 2. The results of the research governed the structure, scope, and procedures for the training, certification, and action-taking components of the MPS(O). Each component is described below.

Develop Action-Taking Component

Effective maintenance requires a combination of skill, knowledge, and motivation from the mechanics who perform maintenance tasks and the supervisors who direct the mechanics. The MPS(O) was designed to take maximum advantage of these factors. Particular emphasis was placed on participation of mechanics in meetings held at the unit level on maintenance-related problems, and the necessary actions required to solve these problems. Supporting research conducted in the early stages of the project on the topic of motivation verified that low levels of maintenance motivation stemmed from insufficient assessment of maintenance performance, lack of feedback of information to work groups, poor communication and co-operation among maintenance personnel,

inadequate preparation for the job, and insufficient understanding by maintenance leaders of the importance of command emphasis. The concept of action-taking via structured action meetings was formulated to promote:

- Performance measurement and feedback
- Responsibility
- Communication and cooperation
- Preparation for the job
- Participation and job improvement
- Recognition of successful performance

The notion of having mechanics contribute to actions to solve maintenance problems was pursued and emphasized in the units so that more could be done in less time, everyone's information could be brought out in the open, efficient communication could be promoted, teamwork could be enhanced, and the relationship of skill to the individual training profiles provided by the MPS(O) could be reinforced. The action-taking sequence supported maintenance by providing a continuing process of data collection, reporting, and assessment/discussion leading to maintenance-improvement actions. The action component of the MPS(O) is described in detail by Stuster & Fuller (1983).

Being a maintenance supervisor in an armor battalion is an onerous task--particularly if one is assigned without job training. The duties required of the Company or Battalion Motor Sergeant are varied and demanding. He must divide his time between administrative and technical activities. The effective Motor Sergeant is a dynamic, well-organized, technically skilled mid-level maintenance manager who directs, teaches, manages, and counsels his mechanics. Unfortunately the Army does not have adequate training available to provide him with these unique skills. Most Motor Sergeants are thus required to learn their skills on-the-job and often do not succeed. This supporting research task (**Development of a curriculum specification for Motor Sergeants**) identified the characteristics of effective Motor Sergeants and translated those characteristics into behavioral components (Dick, Spiker, Harper & Fuller, 1982). The behavioral components were translated further into trainable items that would form the nucleus for a curriculum specification. The notion here was to concentrate on criteria linked to the behaviors the Motor Sergeant must invoke to achieve his objective rather than on the more conventional method of defining components of a job description as a source for training needs. In other words, **what** Motor Sergeants do is well-known, but **how** the effective ones do it is not! The key components of a Motor Sergeant's skills that were appropriate for his training were listed in five modules. The modules described training for skills including:

- Processing information
- Supervising
- Communicating

- Enhancing personnel effectiveness
- Enhancing the work environment

For a description of the curriculum that was developed and submitted to the USAOC&S for use in Motor Sergeant's training see Dick, et al (1982).

Develop Training Component

An objective of the MPS(O) was to help develop maintenance skills in the unit. Department of the Army (DA) policy dictates that the advanced maintenance skills mechanics need must now be learned through on-the-job training (OJT). This type of training occurs on actual equipment located in the working environment with a designated trainer present. The main difference between OJT and on-the-job experience (OJE) is that a trainer/trainee relationship is formally established in OJT. Strong emphasis was therefore placed on designing the Maintenance Training Component of the MPS(O) to fill the unit OJT gap. This component of the MPS(O) has demonstrated strong potential influence on maintenance effectiveness in both the short and long term. It provides a way of identifying skill deficiencies, taking appropriate training action, and measuring results previously unavailable.

A preliminary research task was conducted to develop OJT principles which could be used as guidelines to make OJT in the unit more effective. We reviewed the research findings of psychologists and educators who had focused on appropriate facets of learning theory to help provide sources for derivation of OJT principles. The method to develop these **Training Guidelines Applied to Selected OJT Tasks** is discussed in a report by Harper and McCallum (1981). The transformation of these general principles into practical and specific tips for conducting OJT was made by first listing previously identified maintenance tasks and related performance steps. The performance steps were then coded by action descriptors, e.g., adjust, tighten, calibrate.

The descriptors were grouped into behavioral element categories such as recalling (facts, figures), comparing (matching, measuring), identifying (symbols, locations), etc. Maintenance procedures were matched with the behavioral elements so each task could be described in behavioral terms. The ultimate product of this facet of development of the MPS(O) training component was a comprehensive Handbook for OJT Maintenance Training in DIV 86 Armor Units (Dick, Harper, Wotkins, Wolfe, & Lueb, 1983). The Handbook provided information on: how to train mechanics to use technical manuals, how to teach task knowledge and maintenance procedures, how to help trainees make comparisons, and how to provide feedback. The handbook provided not only a plan for unit-level training, but also all the materials needed to train the unit maintenance trainers, and listed how to qualify mechanic-trainees.

During development of the MPS(O) Training Component a study was conducted (Spiker, 1982), to determine the relationship between OJE and maintenance proficiency. People do learn with practice (experience) but where the learning curve peaks or flattens was undefined, hence this study.

A total of 70 tank automotive mechanics (most with MOS 63N), were individually tested on two M60 tank repair tasks, starter installation and generator installation. The mechanics tested had performed these tasks from 0 to a maximum of 9 or more times prior to testing. Maintenance skill measured on criteria related to TM use, use of tools,

time, and quality was found to increase with OJE. Overall proficiency was greater for those with more experience up to about 6 previous task performances. Surprisingly, there was no additional gain shown for mechanics who had additional performances beyond six. The results are illustrated in Figure 3 and described by Spiker, Wotkyns, and Lueb (1982). Similar relationships were found between experience, skills related to use of the TM, adherence to prescribed repair sequence, selection and use of tools, checks of repair quality, and speed of repair.

The findings from this research had important implications for maintenance training at the unit level. OJE is an effective way to develop maintenance skills. If task assignments are made systematically based on MPS(O) skill profiles, skill growth is likely to be even more dramatic than that demonstrated in this study. However, OJE is only effective for skill growth on tasks that occur frequently in maintenance. Infrequently performed tasks are not appropriate for OJE skill acquisition since adequate opportunities for learning are too sparse to be reinforced from practice.

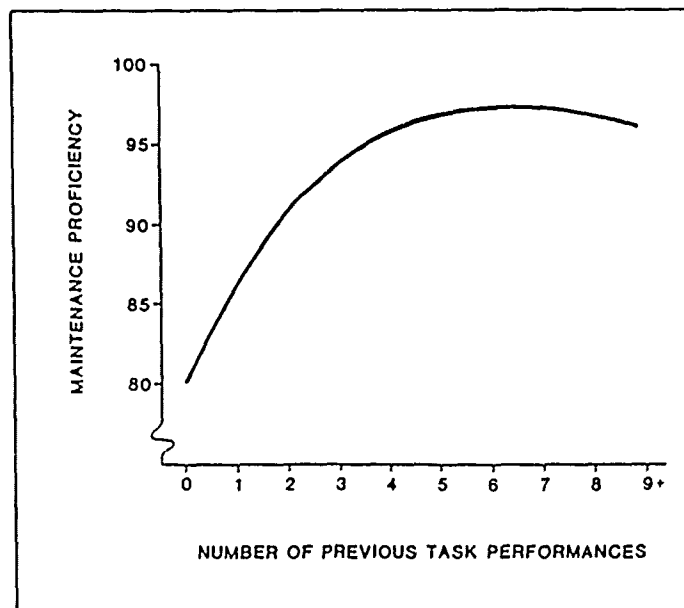


Figure 3. Relationship of previous task performances to maintenance proficiency.

Develop Certification Component

The MPS(O) provides for Mechanic Certification with the unit. Certification provides formal and public recognition of achievement in performance of selected maintenance tasks according to specified criteria. Accordingly, a mechanic can be certified after he has demonstrated technical proficiency and professional competence to established standards under the structure developed for the MPS(O). A certified mechanic thus receives a stamp of professionalism recognized by maintenance leaders, other certified mechanics, and less qualified mechanics for whom he may be providing guidance. Typically Certification is considered as reaching journeyman status in civilian industry, or the equivalent. The MPS(O) automatically handles Certification recordkeeping tasks and provides profiles of qualifications on an individual and task basis.

The MPS(O) Certification Component also provides certification options that can be selected, modified, and used by the unit as desired. One option, for example, was developed to certify a mechanic semi-automatically from MPS(O) records when he had reached specified levels of job experience. Each time the mechanic performed a task, the information was recorded by the MPS(O) and was subsequently reflected in his Experience and Qualification Profile published as a special MPS(O) report. When a mechanic had performed a task a specified number of times, he could be considered qualified.

Another option was where a mechanic could become qualified by demonstrating that he could perform the task satisfactorily. To avoid diluting the value of the certificate, Certification candidates' data was usually verified by a maintenance panel or by senior maintenance supervisors. The standards, criteria, and procedures for certification were defined and listed in a Certification Handbook (Spiker & Wotkyns, 1983).

The development of the four major components comprising the MPS(O) resulted in a streamlined and compact maintenance performance system operable by Army personnel without special prerequisite skills. As finally configured, the MPS(O) encompassed eight maintenance MOSs and the key equipment of an armor and mechanized infantry battalion. The description which follows describes the concept governing the requirement for MPS(O) operation as an integrated system.

MPS(O) DESCRIPTION - THE INTEGRATED SYSTEM

The MPS(O) is a system for keeping maintenance management informed, developing technical maintenance skills, and promoting effective maintenance communication. As a tool for attaining these desired maintenance objectives, the MPS(O) combines the best of the new with the best of the old. Advances in technology permit the system to use a small computer to transform large amounts of maintenance information into concise reports directly usable by maintenance leaders. The system also provides the most efficient ways of learning on the job, developed from recent research results. On the other hand, the system employs management principles that have been developed and tested over many years. A more complete description of the system is provided in an earlier report (Harris, 1983).

Use of the MPS(O) can be totally self-contained within a battalion. Maintenance information is processed and disseminated totally within the battalion. Actions are

taken and decisions made by the leaders, supervisors, and mechanics within the battalion. Training needs are identified and efforts are undertaken to develop needed skills within the battalion. Skill profiles of individual mechanics are maintained within the battalion; they show task-by-task experience and qualifications. In short, the MPS(O) is a flexible tool that has strong potential for helping a battalion attain and sustain superior maintenance performance.

The MPS(O) is an integrated system. The system consists of four separate components/entities--an information processing component, a training component, an action-taking component, and a certification component. However, the real payoff comes when these components all work together as a whole. As shown in Figure 4, the system requires interaction among the four components. For example, action meetings address maintenance reports and other information that are produced and distributed by the information system. This interaction is depicted by the arrow from the information system to action meetings. As shown by the arrow going in the opposite direction, results of the actions taken affect the information collected and processed by the information system. Action meetings also enhance communications within the unit by involving personnel at different levels in the action-taking process.

Some important actions emphasize skill development, as shown by the arrow from action meetings to training. These actions are stimulated by indicators of poor maintenance performance and by skill profiles generated by the information system. Skill development might be a routine and automatic part of the system, or it might involve special actions that emerge from the action-taking process. The arrow from training back to the information system indicates that the results of training efforts and changes in skill profiles are registered by the information system.

Certification is closely tied to this process. When mechanics reach prescribed levels of experience or proficiency, their skill profiles identify the tasks on which they are qualified. Upon becoming qualified on a specified set of tasks, mechanics are certified. Certification provides tangible recognition of the proficiency level a mechanic has attained, and provides a basis for assigning training and supervisory tasks to those who are qualified to perform them.

The MPS(O) encompasses the maintenance MOSs and the combat-related equipment for which they are responsible within a battalion. The test bed for developing and evaluating the MPS(O) consisted of armor and mechanized infantry battalions. In these battalions the system covered the MOS's and equipment listed in Table 2. Note that MOS 63N and MOS 63T also work on wheeled equipment, even though their primary MOS is for tracked vehicle maintenance.

The MPS(O) is an adaptable system. The overall system, as well as its individual components, can be readily modified to meet local requirements. The Information Processing Component, for example, can be expanded or contracted as needed. MOS's and equipment items can be added or deleted, as circumstances change. Also, the Action-Taking, Training, and Certification components provide for substantial latitude in their implementation.

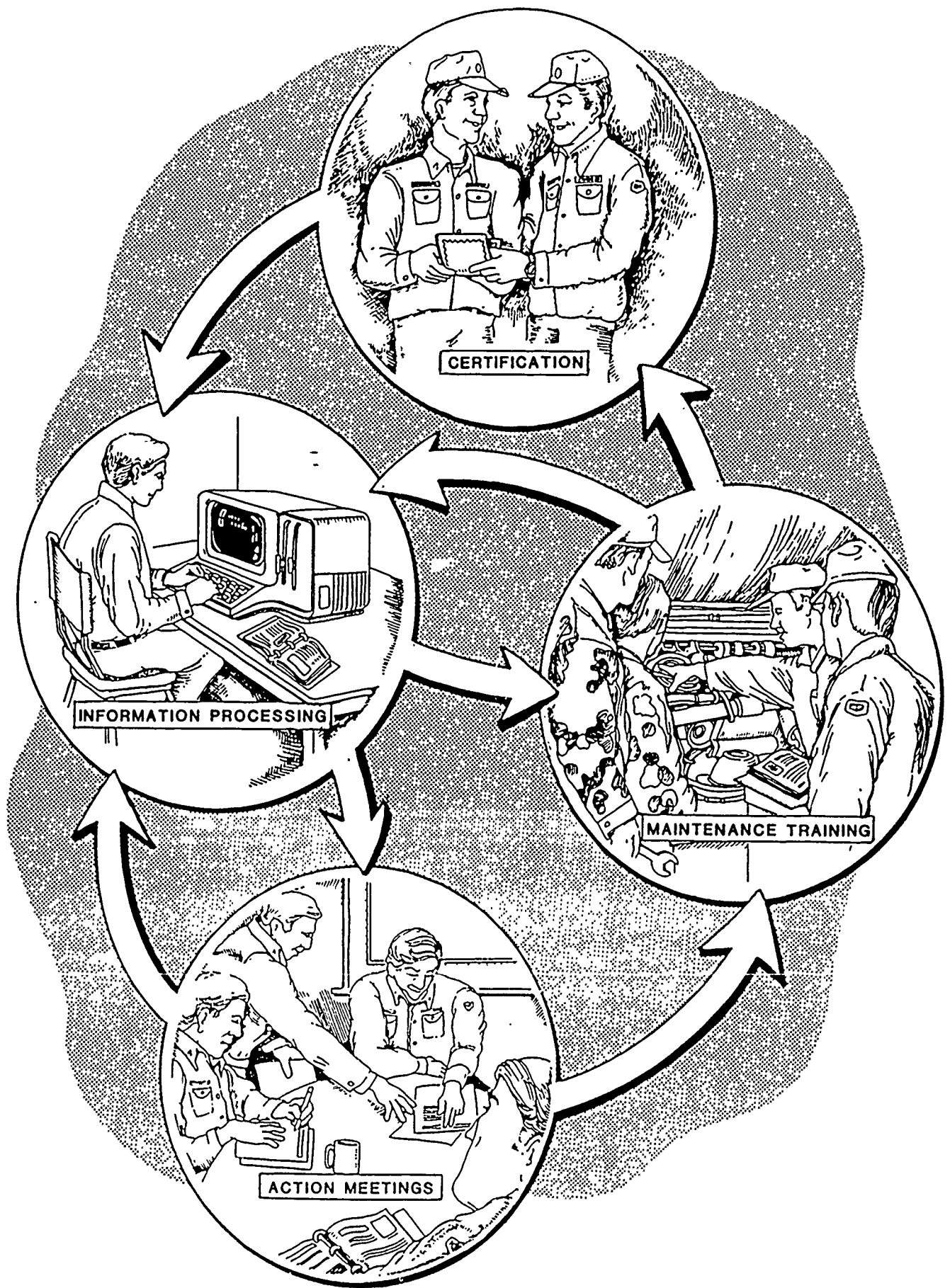


Figure 4. Integrated components of the MPS(O).

TABLE 2
PERSONNEL, EQUIPMENT, AND MAINTENANCE AREAS INCLUDED IN MPS(O)

Maintenance Area	Personnel		Equipment	
	MOS	Title	Desig.	Title
TRACK	63N	Tank System Mech.	M60	Tank
			AVLB	
	63T	ITV/IFV/CFV System Mech.	M113	Personnel Carrier
			M88	Recovery Vehicle
TURRET			M578	Recovery Vehicle
	45N	Tank Turret Mech.	M60	Tank
	45T	ITV/IFV/CFV Turret Mech.	M113	Personnel Carrier
WHEELS			M151	Utility Truck
	63B	Light Wheel Vehicle Mech.	M35	2½ Ton Truck
	63S	Heavy Wheel Vehicle Mech.	M54	5 Ton Truck
	63N	Tank System Mech.	M561	1½ Ton Truck
	63T	ITV/IFV/CFV System Mech.	M792	1½ Ton Truck
			GOER	8-10 Ton Truck Family
COMMO	31V	Tactical Comm System/Op Mech.	Radio	
			Other Commo Equipment	

IMPLEMENTATION

Implementation of the MPS(O) took place in steps (see Figure 2) including: installation of integrated system components, training of Army personnel, and handing over to Army personnel. However, this general plan was influenced by the point in time when units started to participate in MPS(O) operation. For example, the armor battalion which had been associated with MPS(O) development since inception of the project had MPS(O) components installed and tested as they were developed. The second armor battalion did not participate until the last year of the project and received the MPS(O) as a complete system.

Each of these battalions were given a preliminary period of approximately three months for system familiarization. During this time contractor staff operated the system. System operation required collection of data, supervision of data entry, production and distribution of appropriate reports, and interpretation of their content as required. After the three months had elapsed the system was handed over for independent operation by the units. The mechanized infantry battalion was provided the system in the final months of the project and operated under unit auspices immediately without a familiarization period.

IMPLEMENT COMPLETE MPS(O)

Instruction, familiarization, practice and feedback were keystones of the implementation phase. Classes, seminars, briefings, and consultation were provided by the contractor to various levels of unit personnel. Senior officers were provided general summaries of each component and given specific instruction to help them interpret system outputs; maintenance managers and supervisors were trained in the various aspects of Action-Taking, Certification and Maintenance Training according to their duty positions and job responsibilities; and mechanics were briefed on the task qualification and certification process and instructed how to interpret and use their Individual Performance Profiles.

TRAIN UNIT OPERATORS

Before the MPS(O) could be handed over for Army use, two trained system operators were needed by each battalion. Only one is actually required approximately half-time to operate the system. However, a reserve operator should be trained so the system would still function if the primary operator was unavailable. A five-day training course was conducted which covered all key components of the MPS(O) under system operator control. The curriculum for the trainees included roster preparation, data collection, data quality control, entry of maintenance data from the special data forms, and "hands on" practice with the data processing equipment so the operators could become skilled in use of the keyboard and printer. The MPS(O) Operating Manual (Fuller, 1983) served as a course textbook for the training in addition to special material supplied by the contractor.

HAND OVER TO ARMY

The MPS(O) in its final form was handed over at pre-determined times for operation under independent control and responsibility of each unit. The units

comprised the two participating armor battalions and a mechanized infantry unit from the 4th ID (mech.) at Fort Carson, CO. Contractor staff remained on-site as consultants on an "on-call" basis for problem resolution and/or troubleshooting of system operation. At the time of writing of this report, an MPS(O) is being used in each of the three battalions and, at the request of the users, will be left in place beyond the completion of the project.

EVALUATION

An overview of the evaluation plan is provided in Figures 5 and 6. Figure 5 shows the overall evaluation approach and the type of objective and subjective data collected and analyzed. Figure 6 shows the periods of participation in the evaluation by the three battalions. The period of evaluation was from October 1983 through May 1984.

The original evaluation plan (Harper, 1983) assumed that one battalion (mech. infantry) would act as a source of "baseline" measures of maintenance for later comparison with other measures. This battalion was chosen because at that time they had no experience with the MPS(O). They were to be provided with the MPS(O) in mid-March 1984, after which they would be able to provide MPS(O)-influenced data. In this manner, results could be assessed in terms of a "before-after" model. However, because of contract modification delays, the system was not supplied in time for this battalion to provide MPS(O) data. Accordingly, their only contribution was as a source of data from a non-MPS(O)-equipped battalion. However, comparisons between MPS(O) battalions and the non-MPS(O) battalion were risky because armor battalions would be compared with an infantry battalion. Differences in maintenance requirements based on equipment densities would be likely to confound comparisons.

The underlying assumption of MPS(O) development was that use of the system would pay off ultimately in increased maintenance effectiveness. The logic is certainly sound because the MPS(O) provides the information, training, and incentives needed for effective maintenance. However, obtaining empirical evidence that the MPS(O) actually did enhance maintenance effectiveness required data to be collected in a field environment where many uncontrolled variables were at work. As a consequence, ultimate criteria (such as the degree to which a unit was fully-mission-capable (FMC rate)) reflected the interplay of many variables, the effects of which could not be separated. Equipment maintenance in the Army is a complex system subject to the continuous interaction of numerous variables. Chief among these are personnel turbulence, prime equipment age and condition, shop facilities, personnel skills, and repair equipment condition and availability. Local unit decisions such as how units will be organized, focus of command emphasis, and mission assignments, all add to the vagaries of obtaining accurate empirical data. For example, the test battalions lost a high proportion of experienced mechanics and supervisors during the period of evaluation. From the data collected it was not possible to separate the negative impact of personnel turbulence from the positive impact of the MPS(O) on maintenance.

Additionally within the test battalions during the evaluation period, the maintenance structure was altered, companies were exchanged between battalions and, at one point, one of the battalions was informed that its tanks were to be completely replaced with new ones with different maintenance characteristics.

We had to rely in part on intermediate evaluation criteria--that is, criteria reflecting changes in attitude or perceptions of quality derived and summarized from the original responses.

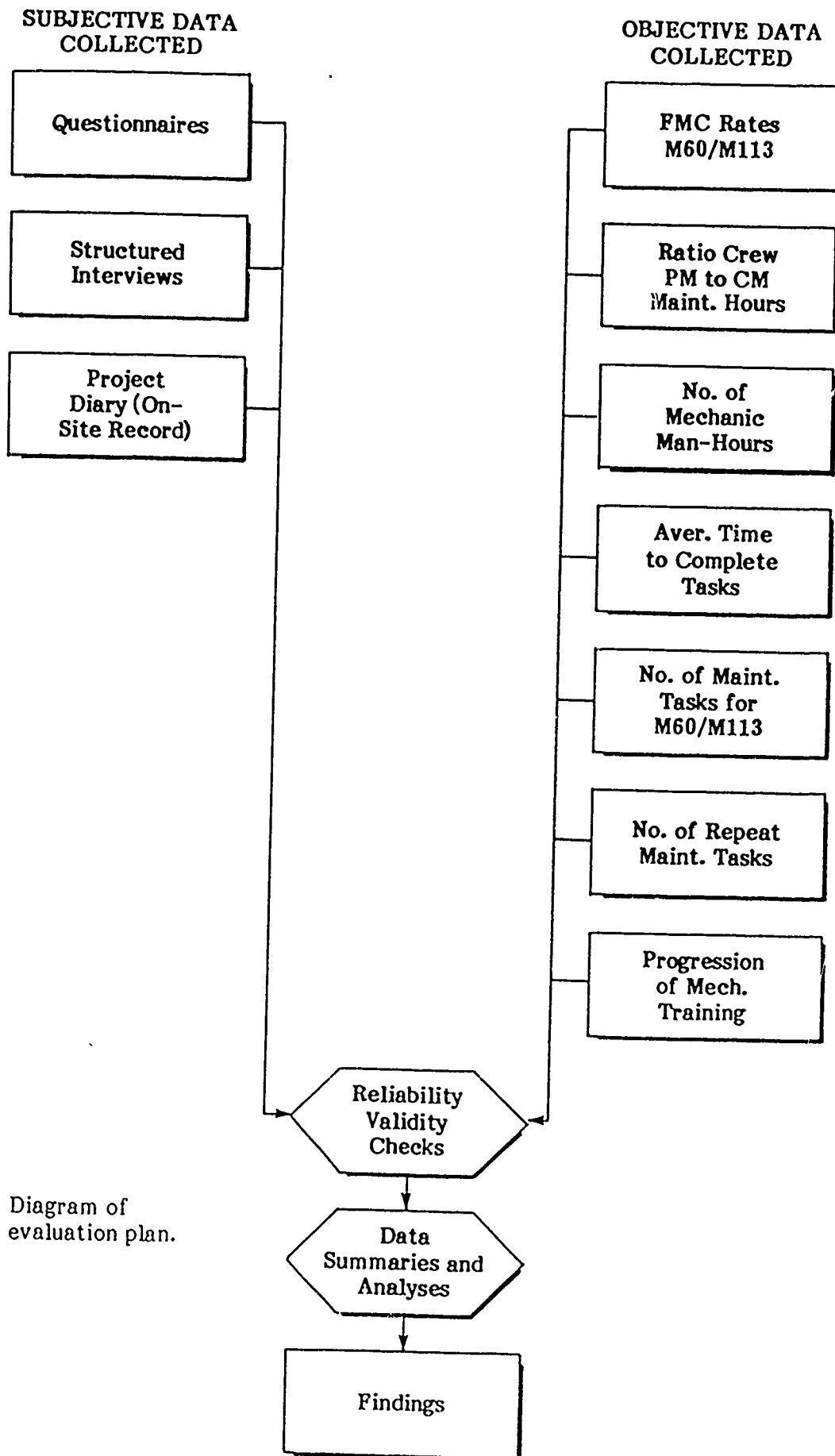


Figure 5. Diagram of evaluation plan.

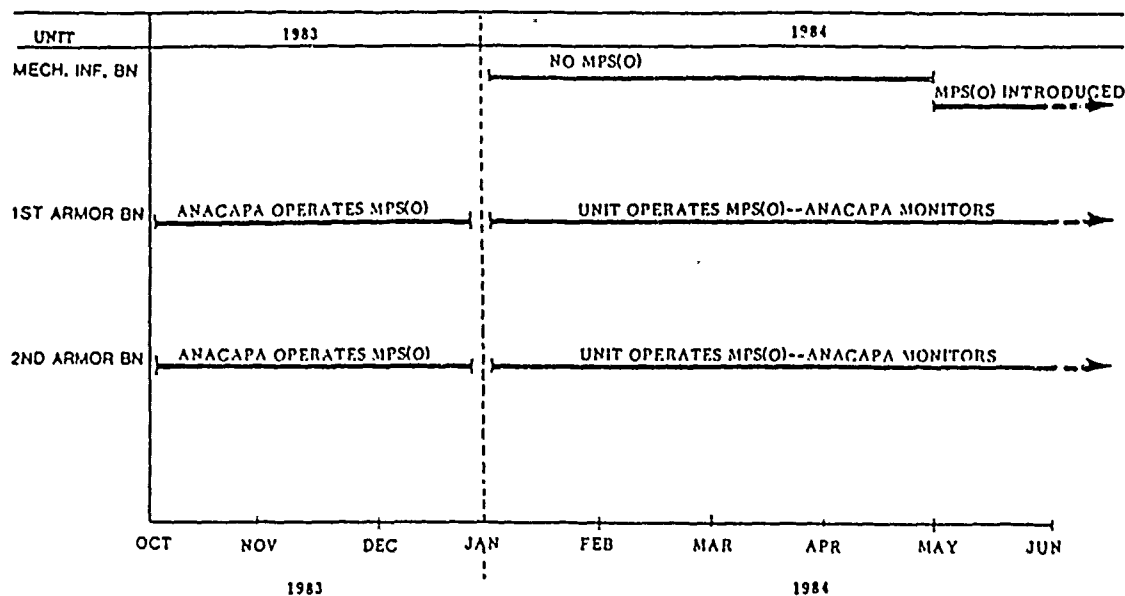


Figure 6. Unit participation periods in MPS(O) evaluation.

The objective measures shown in Figure 5, though generally sound within themselves, were difficult to interpret because of the confounding effect of many uncontrolled variables. A detailed discussion of the analyses of the objective data with examples of each analysis is contained in a separate ARI document.

The analyses that were appropriate for reporting here were reinforced by users' comments, responses to questionnaires, direct observations by contractor staff, and structured interviews. These are discussed in detail in subsequent paragraphs.

Overall, there was a strong consensus from users that the MPS(O) was simple to operate and had potential for enhancing maintenance effectiveness. Our data were not appropriate for computing savings in dollars, however, as the Battalion Commander of an Armor unit with the MPS(O) noted, "...if this system helps avoid needless replacement of just one M60 power pack (\$90,887 as of July 1984), it will more than pay for itself..."

MAINTENANCE EFFECTIVENESS PROFILES

Maintenance effectiveness profiles were constructed from responses obtained through structured interviews with supervisors in two armor battalions in which the MPS(O) had been implemented, and from supervisors in a mechanized infantry battalion which did not have the MPS(O).

The structured interviews were guided by protocols listing five major topic areas--maintenance effectiveness, maintenance information, maintenance training, task qualification/certification, and action-taking. Within each major topic area, three aspects of the topic area were explored. The wording of the protocols differed slightly between the non-MPS(O) and MPS(O) battalions. However, since the protocols were for interviewer use only, the difference did not affect the outcome. Copies of the protocols are attached in Appendix A.

In constructing the non-MPS(O) and MPS(O) profiles, each response statement (i.e., comments made to interviewers) was assessed as being positive, neutral, or negative by a panel of four Anacapa staff members. Three of the panel members were totally naive about Army maintenance. One member had partial knowledge. The panel members did not know with which of the three participating battalions the comments were associated. The assessments were categorized by type and summarized by percentage. The percentage of positive responses is shown in Table 3. There was a high level of agreement among panel members in their independent assessments. For the few assessments in which there was some disagreement, a consensus was easily reached.

Battalions using the MPS(O) had more positive maintenance effectiveness profiles than did the battalion with no MPS(O). For 13 of the 15 elements in the table, maintenance leaders in the MPS(O) battalions (black bar) had more positive assessments than did maintenance leaders in the non-MPS(O) battalion (shaded bar). Also note that leaders using the MPS(O) indicated higher assessments of overall maintenance effectiveness than those not using MPS(O). However, there was essentially no difference in assessments of changes in FMC rates. Apparently, in the view of maintenance leaders and reinforced by our experience in the field, FMC rate changes can be a function of variables other than maintenance effectiveness alone.

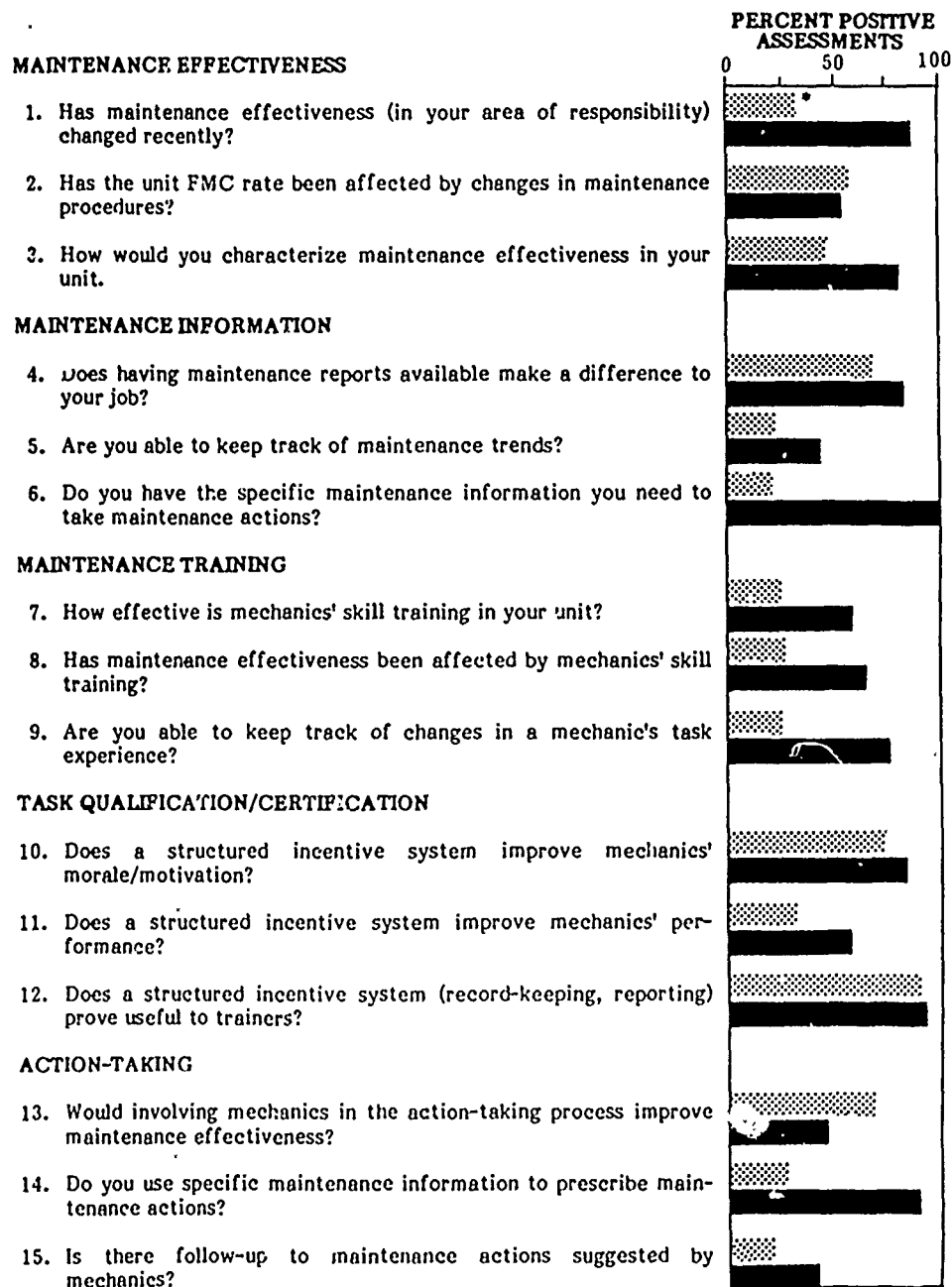
MAINTENANCE EVALUATION QUESTIONNAIRES

To obtain information on MPS(O) application and results, responses were provided by maintenance supervisors and mechanics to maintenance evaluation questionnaires designed to explore the availability of maintenance information, adequacy and quality of maintenance information, impact of training, adequacy of maintenance problem-solving, and the adequacy of various maintenance practices and procedures.

The questionnaires required ratings from maintenance supervisors and mechanics on five-point scales, requiring responses related to percentage, categories of agreement, or frequency. Copies of the supervisors and mechanics questionnaires are provided in Appendix B. Each question was averaged to show the percentage of respondents for each of the five points on the rating scale. The total percentage of responses (above a 50% arbitrary criterion figure) for the two sections of the supervisors questionnaire, were computed and formed the basis for the results reported later in Figure 7 on page 28. The sections were based on the two major stems for questions asked of the supervisors such as "what percentage of available information do you have now concerning...?" and "how strongly do you agree that...?"

The mechanized infantry battalion with no MPS(O) experience and the two armor battalions with limited experience all received the first administration of the questionnaires. But only the two battalions with MPS(O) experience were asked to respond to the same questionnaire six months later. The non-MPS(O) battalion was not given the second questionnaire because of lack of experience with the MPS(O).

TABLE 3
MAINTENANCE EFFECTIVENESS PROFILES FOR
MPS(O) AND NON-MPS(O) BATTALIONS



•KEY: = Non-MPS(O) Bn = MPS(O) Bns

The data from the questionnaire are considered reliable. Thirty-eight supervisors (from both battalions combined) responded in January and 29 responded in June. Sixty-three mechanics responded in January and 74 responded in June. During the six months between the first and second administration, approximately 40% of the personnel were reassigned. However, since the questionnaire was primarily geared toward characteristics of the jobs filled by the incumbents, the respondents reflected the status of the system in January and the status of the system six months later. The incumbents' tasks, and the components of the MPS(O), did not change during the elapsed time.

AVAILABILITY AND ADEQUACY OF NEEDED INFORMATION

In a longitudinal assessment of the impact of the MPS(O) from the questionnaire data, maintenance information needs were found to be satisfied better as the MPS(O) was used longer. The benchmark was data from the battalion with no MPS(O). As noted earlier, extreme caution is required when comparing non-MPS(O) and MPS(O) battalion data because of basic differences between the armor and mechanized infantry battalions. The same questionnaire was also administered to the MPS(O) battalions at the 3-month and 9-month points in their MPS(O) use. The MPS(O) units were provided the system on a limited basis for three months. Then, they operated it themselves for six months. The questionnaires were administered first at the end of the 3-month period, and again at the end of the 9-month period. This represented an elapsed time of 6 months (Figure 6, previously cited, illustrates in graphic form the points in time when the questionnaire was administered).

As shown in Figure 7, the extent to which maintenance information needs of supervisors was satisfied increased over the 6-month period under examination. Specifically, the figure shows the percentage of supervisors who claimed that at least half of their maintenance information needs were satisfied.

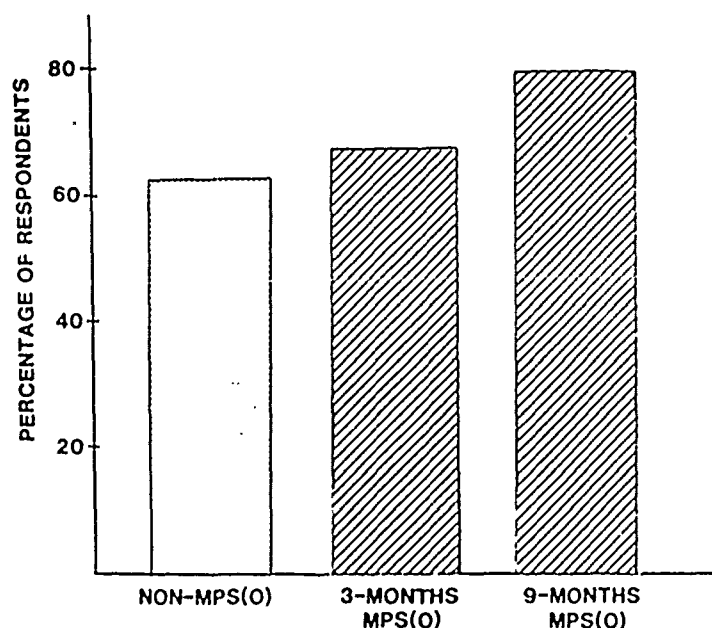


Figure 7. Percentage of supervisors with maintenance information needs satisfied.

On the other hand, there were essentially no differences over time relative to the adequacy of the content or quality of maintenance information. About 80% of the supervisors from MPS(O) battalions were satisfied with at least half of the information they obtained, at both the 3-month and 9-month periods. About 75% of the supervisors from the non-MPS(O) battalion were satisfied. The conclusion is that apparently supervisors were reasonably well satisfied with the adequacy (content) of what information was obtained, regardless of the source.

MECHANICS' ASSESSMENT OF MAINTENANCE EFFECTIVENESS

From the perspective of the mechanics themselves, maintenance effectiveness increased with use of the MPS(O). From the mechanics point of view, maintenance effectiveness is defined by how jobs are assigned, whether structured OJT is done, if they participate in actions to correct problems, if records are kept of who does what tasks, and the like. As shown from the composite of their responses in Figure 8, the percentage of mechanics who provided positive assessment of maintenance practices increased over time.

Examples of responses to two questions in the supervisors' questionnaire are provided in Figures C1, C2, C3, and C4 contained in Appendix C. The graphs show: the percent of respondents who replied to each of the five response points on a scale, and the data from each administration of the questionnaire for each armor battalion. Note the positive shift in responses over time in the samples provided.

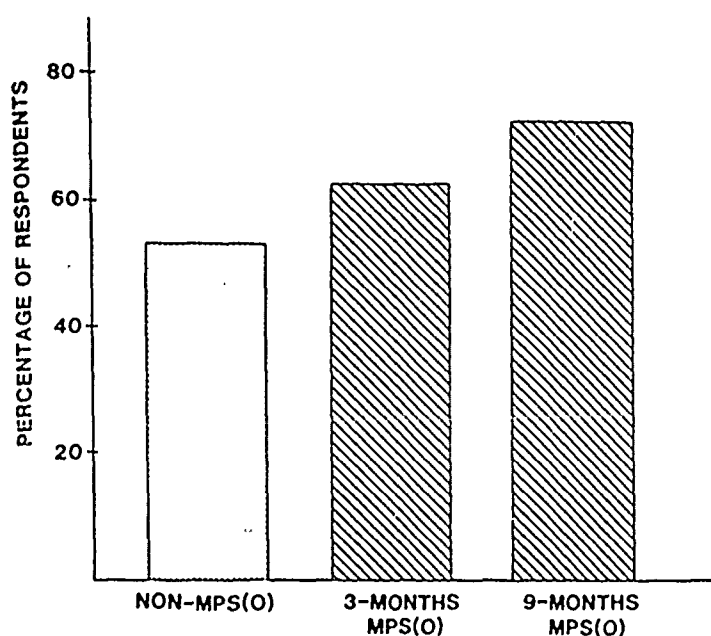


Figure 8. Mechanics' assessment of maintenance effectiveness in MPS(O) and non-MPS(O) battalions shown by percentage of tasks recorded during 16-week period.

Two similar examples for mechanics are provided in Figures C5, C6, C7, and C8, also in Appendix C. The mechanics showed a similar positive shift between the administrations of the questionnaire.

MPS(O) OPERATION RECORD

This record took the form of a diary maintained onsite to capture subjective comments made by users in a formal record and to note events related to MPS(O) operation that typically would not appear in the "Interpretation Comments" report. The remarks made by users amplified and reinforced information obtained by other means.

One example of the information collected was an observation by the Battalion Maintenance Technician of an Armor Battalion that MPS(O) Management Report #6 (Maintenance Task Performance Data by Vehicle) indicated no daily checks were being made by crews of M88 recovery vehicles. He directed the Battalion Motor Sergeant to take appropriate corrective action.

Another example was the BMO's decision to improve electrical troubleshooting skills of company mechanics because MPS(O) Management Reports 4 (Combat Vehicle Corrective Maintenance Summary), 5 (Maintenance Tasks by Vehicle), and 6 (Maintenance Task Performance Data by Vehicle) indicated excessive numbers of repeated tasks in electrical repairs.

MAINTENANCE QUALITY

A reliable index of maintenance quality was developed from MPS(O) reports of repeated tasks. A repeated task is defined as a corrective maintenance task that was done more than once during the reporting period for the same vehicle. In other words, the task had to be performed again due to the inadequacies in the maintenance work. The primary objective of identifying repeated tasks was to investigate possible causes linked to poor skill levels which could be corrected by unit training.

As shown in Figure 9, the MPS(O) battalions had significantly fewer repeated tasks than did the non-MPS(O) battalion. The comparison is made for a 16-week period during which valid data were available for all battalions. During this period, a total of 472 corrective maintenance tasks on M60 and M113 vehicles were recorded as being performed in the non-MPS(O) battalion, and 1,212 corrective maintenance tasks were recorded as being performed in the MPS(O) battalions on the same vehicles. Of these totals 17% (80 Repeats) and 14% (170 Repeats) were recorded, respectively, for the non-MPS(O) and MPS(O) battalions.

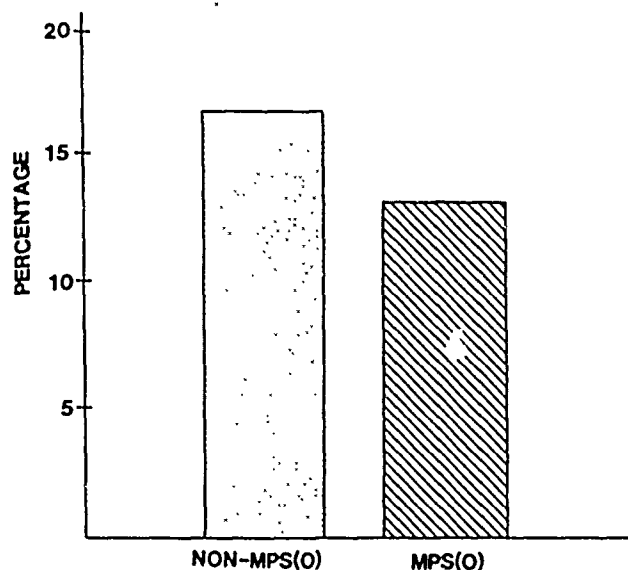


Figure 9. Tasks repeated in non-MPS(O) and MPS(O) battalions shown by percentage of tasks recorded during 16-week period.

BATTALION ASSESSMENT OF THE MPS(O)

One of the armor battalions noted changes in maintenance effectiveness over an 18-24 month period which included the 9-month period of MPS(O) operation. The key results of this separate evaluation were summarized in a letter from the Battalion Maintenance Technician of an Armor Battalion with the MPS(O) to the Commander, Army Research Institute. They are listed below:

- **Mechanics spent more time on maintenance.** With the increased visibility provided by the MPS(O) of how mechanics spend their time, maintenance leaders were able to increase actual mechanic "shopwork" hours from an average of 4 to 17 hours per week.
- **Crew spent more time on preventive maintenance.** A desirable objective in increasing maintenance effectiveness is to emphasize preventive maintenance by crew members. Preventive maintenance by the crew at relatively low cost reduces more costly corrective maintenance by mechanics later. With the aid of the MPS(O), crew preventive maintenance hours increased from an average of 4 hours per week to an average of 10 hours per week.
- **Certified mechanics.** Before MPS(O) implementation, there was no practical way to certify the proficiency of mechanics. During the period in which the MPS(O) was implemented in the battalion 14% of the mechanics became certified as a consequence of proficiency gained through task performance and qualification. Twenty-five percent of the mechanics had become qualified on the total task inventory for all equipment in the battalion.

- **More efficient skill acquisition by new mechanics.** Prior to installation of the MPS(O), there was no structured maintenance training for newly assigned personnel. With the MPS(O) training component, skill upgrading to satisfactory proficiency levels takes between 30-90 days, depending upon aptitude and prior competency.
- **Improved quality of maintenance.** The number of maintenance tasks needed to be repeated because of errors and other performance inadequacies was reduced.
- **Increased equipment serviceability.** The equipment serviceability rate (still used unofficially as a criterion of maintenance effectiveness) as reflected by battalion records, improved during the period the MPS(O) was used for maintenance management.

While these changes occurred in a dynamic environment in which MPS(O) was only one of the operative variables, the battalion maintenance managers concluded that MPS(O) had contributed significantly to these improvements. Additionally, it is important to note that it is not feasible to track continuously all but the last of these measures without a system like MPS(O).

NATIONAL TRAINING CENTER EVALUATION

During the period of the MPS(O) evaluation, one of the participating armor battalions took part in tactical training at NTC, Fort Irwin, California. The battalion was cited highly for first-class combat service support and maintenance during battle training. This was particularly notable inasmuch as this battalion had a relatively poor history of maintenance performance prior to MPS(O) installation.

The evaluation was based on "Official Use Only" unit reports provided by the umpire/controllers of the NTC staff and comments made during the exercise "out-brief." The rating of "high" as applied to combat service support and unit maintenance was based on informal NTC criteria related to: overall completion of the battle (exercise) mission; how accurately and quickly mechanics diagnosed and corrected a repair-related problem; how well the definition and supply of repair parts was handled; how well repairs requiring DS level assistance were arranged and evacuated by the organizational maintenance team; and how well the Battalion Maintenance Officer was able to assess his repair needs and assign appropriate personnel. The MPS(O) provided information for much of onsite management decisions on maintenance. The training component of MPS(O) contributed to skill development in the unit before participation in NTC training.

RESULTS

MPS(O) DEVELOPMENT

The MPS(O) was developed to aid maintenance leaders, mechanics, and equipment operators in performing maintenance effectively. Its components were designed to keep leaders informed, facilitate the growth of maintenance skills, and enhance communications and coordination. Its development was influenced greatly by operational problems encountered by those responsible for equipment readiness in participating units. Furthermore, the MPS(O) has been tested extensively in the field; test results have served to refine the system, making it more useful, flexible, and easier to use.

MPS(O) ACCEPTANCE

The MPS(O) is well-accepted by maintenance personnel in armor and mechanized infantry battalions. Furthermore, as reflected by the evaluation results, response to the system becomes more positive the longer the system is used. At the completion of this project, maintenance leaders at Fort Carson, Colorado, were making arrangements to continue the MPS(O) in the test battalions and considering expanding MPS(O) application in additional battalions.

MPS(O) FLEXIBILITY

Best results will be obtained if the MPS(O) is adapted to the needs of the unit. The system has great flexibility and can be modified in many ways. These are detailed in supporting documents. For example: maintenance leaders can select from three different mechanic certification programs; skill growth can be promoted through an optimum combination of OJE and OJT; accurate and timely profiles of individual's task performance can be recorded and maintained; Motor Sergeants can be provided "how-to-train" skills without attending institutional courses; and the information system can cover all of the MOS's and equipment in the battalion or be selective in its coverage.

MPS(O) OPERATION UNDER FIELD CONDITIONS

The MPS(O) met its design objective of being able to operate when the battalion was geographically dispersed. The operating conditions were similar to those encountered in Europe where units are dispersed by companies and sections to reduce vulnerability from mass attack, and also to use existing facilities under the NATO agreements (Fuller and Harper, 1982).

Tactical training in Continental United States (CONUS) by MPS(O) battalions demonstrated MPS(O) use in dispersed conditions. It was also gratifying to find that though the demonstrated MPS(O) used a commercial (i.e., non-Military Specification) off-the-shelf computer, it worked satisfactorily in field exercises without modification.

RELATIONSHIP TO OTHER MAINTENANCE SYSTEMS

The MPS(O) does not duplicate management and training information available from other Army maintenance and/or training systems. Systems studied during the project (Jarosz, 1981) included the Standard Army Maintenance System (SAMS), the

Maintenance Activity Management System (MAMS), Maintenance Control System (MCS), the Unit-Level Logistics System (ULLS), and the Battalion Maintenance Management System (BMMS). Although these systems share similar overall objectives, they do not provide any of the information provided by the MPS(O). Rather, the MPS(O) provides unique information that will complement that provided by these systems.

MPS(O) EVALUATION POSTSCRIPT

Much of the objective data collected over the evaluation period could not be used. As discussed earlier, the variables which exist in a unit maintenance environment and influence effectiveness are many and uncontrolled from an experimental point of view. For example, data on FMC rates collected as a base-line measure of maintenance effectiveness could not be partitioned by causal components and as a consequence were rejected. Since variables in the field environment could not be held constant, this condition resulted in extensive use of the intermediate criteria and measures discussed earlier.

CONCLUSIONS

- The MPS(O) helps maintenance leaders, mechanics, and crews perform effective maintenance and increases maintenance awareness at all levels within the line battalions.
- Components of the system provide unique pro-active maintenance management and training information to maintenance leaders. The components also provide management with historical information leading to corrective actions for unit maintenance problems.
- The system will operate in USAREUR-like conditions.
- The prototype MPS(O) has been demonstrated to be flexible, easily adaptable to unit needs, and well accepted by users.
- The systems (or components thereof) should be incorporated into other Army computer-based maintenance or logistics systems. Implementing the MPS(O) as an entity with its own minicomputer is not an appropriate option.
- The high rate of personnel turbulence encountered in the MPS(O) battalions inhibited their capability to fully utilize the system's potential to build and maintain an adequate base of technical maintenance skills.
- The evaluation of a prototype system (such as the MPS(O)) under uncontrolled operational conditions requires a longer period than the nine months allotted to evaluation of this project. The effects of personnel turbulence, changes in equipment and procedures, administrative interference, mission accomplishment demands, etc., would thus be smoothed over a longer period.
- The MPS(O) has demonstrated an outstanding capability to amass and process complex information. Without this capability, the examination of results during the evaluation would not have been possible.
- The MPS(O) has potential for acting as a unique repository of maintenance data for other research projects focused on Army maintenance. If controls were instituted during future maintenance data collection to reduce variations and possible gaps in the data before entry in the MPS(O), the value of this longitudinal data would be enhanced for Army researchers from agencies such as ARI, Deputy Chief of Staff, Logistics (DCSLOGS) and USAOC&S.
- The MPS(O) structure and data bases contain information that could be used as source data for maintenance performance research. The MPS(O) consists of several unique data bases dealing with skill acquisition, job times, jobs done more than once, and the like, which will be enhanced as system operation continues.

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APPENDIX A

EVALUATION INTERVIEW PROTOCOLS FOR NON-MPS(O) AND MPS(O) UNITS

RESEARCH PARTICIPANT INFORMATION SHEET*

NAME OF ITEM: Organizational Maintenance Evaluation Interview Protocol

PRINCIPAL PURPOSE/OBJECTIVE:

The results of the interviews will be used as a subjective component in assessing the effect of a Maintenance Performance System on organizational level maintenance and training in Armor and mechanized infantry battalions.

PROCEDURES/DATA COLLECTION METHODS:

Maintenance managers and supervisors with no experience in the MPS(O) will be interviewed. Maintenance and training-related issues will be discussed according to a structured set of topics. The interview is estimated to take approximately 30 minutes.

RESEARCH ORGANIZATION AND STAFF:

Anacapa Sciences, Inc. (Under Army Research Institute Contract MDA903-81-C-0032)

P.O. Drawer Q
Santa Barbara, CA 93105

Mr. W. R. Harper
Mr. A. L. Wotkyns
Mr. R. G. Fuller
Dr. V. A. Spiker

YOUR RIGHTS AS A PARTICIPANT

- Your participation in this research is strictly voluntary.
- There will be no effect on individuals for not participating in the research.
- You are free to withdraw your consent and discontinue participation at any time without prejudice.
- You have a right, and are encouraged, to ask questions about the research.
- If you consent orally to participate, your consent is subject to the same standards as written consent, except no signature is needed.
- The data collected is confidential. Identifiers (Name or SSN) are used for administrative and control purposes only.
- You will not be submitted to any physical or mental risk in this project.
- You may detach this sheet and retain it if you wish.

*This sheet provides data mandated by, under authority of, and in conformity with:

- 10-USC-Sec. 4503
- The Privacy Act of 1974 (5 U.S.C. 552a)
- Directive AR 70-1
- Appendix A to ARI Reg. 70-25 (1 Aug 79)
- Code of Federal Regulations, Title 45, Sec. 46.6(B)

(Form approved ARI 2 Aug 1982)

INTERVIEWER'S GUIDE*
EVALUATION INTERVIEW PROTOCOL
(For Users in Units Without the MPS(O))

Unit: _____

Respondent Name: _____

To be completed
by interviewer.

Duty Position: _____

Date: _____

Maintenance Effectiveness:

1. Has maintenance effectiveness (in your area of responsibility) changed in the last three months?
2. Has the unit FMC rate been affected by changes in maintenance procedures?
3. How would you characterize maintenance effectiveness in the last three months?

Maintenance Information:

4. Would the availability of special maintenance reports make a difference to your job?
5. Assuming that knowing trends in maintenance is useful, how do you keep track of these trends?
6. What specific maintenance information do you need, and don't have, to take maintenance actions?

Maintenance Training:

7. How effective is mechanics' skill training at this time?

*This is an interviewer's aid to ensure that topics are not missed. It will not be distributed to respondents though they may see it if they so request.

8. Has maintenance effectiveness been affected by mechanics skill training?
9. How do you keep track of changes in a mechanic's task experience?

Task Qualification/Certification:

10. Would a structured incentive system improve mechanics' morale/motivation?
11. Would a structured incentive system improve mechanics' performance?
12. Would the structure involved in running a qualification/certification system (record-keeping, reporting) be useful to trainers?

Action-Taking:

13. Would involving mechanics in the action-taking process improve maintenance effectiveness?
14. What special maintenance information do you use to prescribe maintenance actions?
15. Is there follow-up to maintenance actions?

RESEARCH PARTICIPANT INFORMATION SHEET*

NAME OF ITEM: Organizational Maintenance Evaluation Interview Protocol

PRINCIPAL PURPOSE/OBJECTIVE:

The results of the interviews will be used as a subjective component in assessing the effect of a Maintenance Performance System on organizational level maintenance and training in Armor and mechanized infantry battalions.

PROCEDURES/DATA COLLECTION METHODS:

Maintenance managers and supervisors with experience of the MPS(O) will be interviewed. Maintenance and training-related issues will be discussed according to a structured set of topics. The interview is estimated to take approximately 30 minutes.

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- Code of Federal Regulations, Title 45, Sec. 46.6(B)

(Form approved ARI 2 Aug 1982)

INTERVIEWER'S GUIDE*
EVALUATION INTERVIEW PROTOCOL
(For Users in Units With the MPS(O))

Unit: _____

Respondent Name: _____

To be completed
by interviewer

Duty Position: _____

Date: _____

Maintenance Effectiveness:

1. Has maintenance effectiveness (in your area of responsibility) changed since getting the MPS(O)?
2. Has the unit FMC rate been affected by changes in maintenance procedures since getting the MPS(O)?
3. How would you characterize maintenance effectiveness since getting the MPS(O)?

Maintenance Information:

4. Does the availability of special MPS(O) maintenance reports make a difference to your job?
5. Assuming that knowing trends in maintenance is useful, how do you keep track of these changes since getting the MPS(O)?
6. What specific MPS(O) maintenance information do you find useful to take maintenance actions?

Maintenance Training:

7. How effective is mechanics' skill training since MPS(O) was installed?
8. Has maintenance effectiveness been affected by mechanics skill training since MPS(O) was installed?

*This is an interviewer's aid to ensure that topics are not missed. It will not be distributed to respondents though they may see it if they so request.

9. How effective is the way you keep track of changes in a mechanic's task experience since MPS(O) was installed?

Task Qualification/Certification:

10. Does a structured incentive system linked to qualification/certification improve mechanics' morale/motivation?
11. Has the structured incentive system linked to task qualification/certification improved mechanics' performance?
12. Has the structure involved in running a qualification/certification system (record-keeping, reporting) proved useful to trainers?

Action-Taking:

13. Has involving mechanics in the action-taking process improved maintenance effectiveness?
14. What special maintenance information from MPS(O) reports do you use to prescribe maintenance actions?
15. Is there follow-up to maintenance actions resulting from action meetings?

APPENDIX B

**ORGANIZATIONAL MAINTENANCE
EVALUATION QUESTIONNAIRES
FOR SUPERVISORS AND MECHANICS**

RESEARCH PARTICIPANT INFORMATION SHEET*

NAME OF ITEM: Organizational Maintenance Evaluation Questionnaire

PRINCIPAL PURPOSE/OBJECTIVE:

The information acquired will be used to assess the effect of a Maintenance Performance System on organizational level maintenance and training in Armor and Mechanized Infantry battalions.

PROCEDURES/DATA COLLECTION METHODS:

Selected participants from appropriate maintenance duty positions will be asked to complete a short (approximately 40 questions) questionnaire. Responses require indicating agreement on a scale ranging from 1 (disagree) to 5 (agree) and on a second scale ranging from none to 100%.

RESEARCH ORGANIZATION AND STAFF:

Anacapa Sciences, Inc. (Under Army Research Institute Contract MDA903-81-C-0032)
P.O. Drawer Q
Santa Barbara, CA 93105

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- Directive AR 70-1
- Appendix A to ARI Reg. 70-25 (1 Aug 79)
- Code of Federal Regulations, Title 45, Sec. 46.6(B)

(Form approved ARI 2 Aug 1982)

ORGANIZATIONAL MAINTENANCE EVALUATION QUESTIONNAIRE

PURPOSE

This questionnaire is for key maintenance personnel in armor and mech. infantry units at Fort Carson. Your answers will help us improve organizational maintenance. The questionnaire is short and should take you about 15 minutes to complete.

You already know that effective organizational maintenance is essential to the success of unit missions. Maintenance experts believe that organizational maintenance is the foundation of the Army maintenance pyramid.

The Army has contracted with Anacapa Sciences to investigate maintenance problems from several different angles. Anacapa Sciences has developed a organizational maintenance performance system which is being tested by selected units.

We have spent many hours interviewing maintenance leaders such as yourself. We are familiar with organizational maintenance problems and have developed ideas for solving some of them. But, before we can report on the effect of these ideas on maintenance, we need some baseline and user data on maintenance effectiveness in your unit.

To be completed by interviewer.

1. Name _____
2. Unit _____
3. Rank _____
4. Duty Position (check box below)

- | | |
|---------------------------------------|--|
| <input type="checkbox"/> Bn Commander | <input type="checkbox"/> Co Cdr |
| <input type="checkbox"/> Bn XO | <input type="checkbox"/> Co XO/Motor Officer |
| <input type="checkbox"/> S3 | <input type="checkbox"/> Motor Sergeant |
| <input type="checkbox"/> BMO | |
| <input type="checkbox"/> BMT | |
| <input type="checkbox"/> BMS | |

MAINTENANCE MANAGER/SUPERVISOR QUESTIONNAIRE

INSTRUCTIONS

- Read this set of statements and check one box from the five choices opposite each question.
- Note that questions apply only to conditions in this unit --- today!

1. What percentage of available information do you have now concerning:

	None	25%	50%	75%	100%
-- The total number of maintenance tasks completed by each mechanic	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
-- Which mechanics are qualified to perform most tasks without supervision	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
-- The specific maintenance tasks each mechanic has done	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
-- Which mechanics lack experience to perform critical maintenance tasks	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
-- The average amount of time each mechanic has spent on each maintenance task	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
-- The increase in mechanics' overall experience level during the last several months	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
-- How much time each mechanic has available to perform unit maintenance versus other duties	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
-- Which mechanics are capable of taking part in on-the-job maintenance training activity as a lead mechanic	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
-- Maintenance jobs repeated often, suggesting improper maintenance	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

--Go to next page--

1. (Continued) What percentage of available information do you have now concerning:

	None	25%	50%	75%	100%
-- Maintenance tasks that require excessive time, suggesting a need for training	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
-- Which mechanics should be formally recognized for outstanding maintenance skill/performance	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
-- Which mechanics could benefit by being assigned to jobs that would add to their job experience	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
-- How mechanics could provide input to help maintenance decisions	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
-- Which repair tasks/jobs do not have enough mechanics qualified to work on them	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
-- Which mechanics need structured training on particular maintenance tasks	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
-- Which vehicles have required excessive maintenance	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
-- What maintenance tasks recent AIT graduates can do on arrival	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
-- Specific repairs that problem vehicles have had in the last six months	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
-- Which experienced mechanics have received a certificate of proficiency this year	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
-- Results from actions developed from a discussion of maintenance problems	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

--Go to Question 2 on the next page--

2. How strongly do you agree that:

- Maintenance information managers/supervisors now have in this unit is accurate and valid
- Structured/supervised OJT has improved maintenance skill in this unit
- Having a qualification plan for maintenance tasks directly affects maintenance performance
- Maintenance managers/supervisors can prescribe solutions to maintenance problems with information they now receive
- Maintenance effectiveness in the unit has changed in the last six months
- In this unit, mechanics know exactly how often they've performed repair tasks
- Formal recognition of maintenance skill is a strong motivator for mechanics in this unit
- Maintenance manager/supervisors in this unit react to problems more than they act to prevent problems
- In this unit, we can easily recognize maintenance problems from current summaries
- Knowing how many times a mechanic has done a task has affected training decisions
- Publishing comparative experience lists in this unit for mechanics indirectly influences maintenance performance

Completely Disagree	Generally Disagree	Undecided	Generally Agree	Completely Agree
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Completely Disagree	Generally Disagree	Undecided	Generally Agree	Completely Agree
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Completely Disagree	Generally Disagree	Undecided	Generally Agree	Completely Agree
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Completely Disagree	Generally Disagree	Undecided	Generally Agree	Completely Agree
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Completely Disagree	Generally Disagree	Undecided	Generally Agree	Completely Agree
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Completely Disagree	Generally Disagree	Undecided	Generally Agree	Completely Agree
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Completely Disagree	Generally Disagree	Undecided	Generally Agree	Completely Agree
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Completely Disagree	Generally Disagree	Undecided	Generally Agree	Completely Agree
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Completely Disagree	Generally Disagree	Undecided	Generally Agree	Completely Agree
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Completely Disagree	Generally Disagree	Undecided	Generally Agree	Completely Agree
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

--Continue on the next page--

2. (Continued) How strongly do you agree that:

- Including mechanics in action decision-making has influenced maintenance effectiveness in this unit
- Data is used in this unit relating repeated tasks on specific equipment to a particular mechanic
- Training new AIT graduates has been simplified by use of structured OJT
- Award of a mechanics proficiency certificate in this unit requires an ability to demonstrate correct procedures to apprentices
- Taking decisive action on maintenance problems in this unit is possible from maintenance reports we now have
- Unit data is used in this battalion to relate FMC rate to number of repairs
- Knowing mechanics' experience level on PM/CM tasks in this unit governs job assignments
- In this unit, recognition of mechanics skill (via certification) implies command emphasis on maintenance
- Follow-up to assess results is usually taken in this unit on maintenance actions

Completely Disagree	Generally Disagree	Undecided	Generally Agree	Completely Agree
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Completely Disagree	Generally Disagree	Undecided	Generally Agree	Completely Agree
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Completely Disagree	Generally Disagree	Undecided	Generally Agree	Completely Agree
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Completely Disagree	Generally Disagree	Undecided	Generally Agree	Completely Agree
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Completely Disagree	Generally Disagree	Undecided	Generally Agree	Completely Agree
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Completely Disagree	Generally Disagree	Undecided	Generally Agree	Completely Agree
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Completely Disagree	Generally Disagree	Undecided	Generally Agree	Completely Agree
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Completely Disagree	Generally Disagree	Undecided	Generally Agree	Completely Agree
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Completely Disagree	Generally Disagree	Undecided	Generally Agree	Completely Agree
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

STOP!!

RESEARCH PARTICIPANT INFORMATION SHEET*

NAME OF ITEM: Organizational Maintenance Evaluation Questionnaire

PRINCIPAL PURPOSE/OBJECTIVE:

The information acquired will be used to assess the effect of a Maintenance Performance System on organizational level maintenance and training in Armor and Mechanized Infantry battalions.

PROCEDURES/DATA COLLECTION METHODS:

Selected mechanics from appropriate maintenance MOSS will be asked to complete a short (approximately 10 questions) questionnaire. Responses require indicating agreement on a five-point scale.

RESEARCH ORGANIZATION AND STAFF:

Anacapa Sciences, Inc. (Under Army Research Institute Contract MDA903-81-C-0032)
P.O. Drawer Q
Santa Barbara, CA 93105

Mr. W. R. Harper
Mr. A. L. Wotkyns
Mr. R. G. Fuller
Dr. V. A. Spiker

YOUR RIGHTS AS A PARTICIPANT

- Your participation in this research is strictly voluntary.
- There will be no effect on individuals for not participating in the research.
- You are free to withdraw your consent and discontinue participation at any time without prejudice.
- You have a right, and are encouraged, to ask questions about the research.
- If you consent orally to participate, your consent is subject to the same standards as written consent, except no signature is needed.
- The data collected is confidential. Identifiers (Name or SSN) are used for administrative and control purposes only.
- You will not be submitted to any physical or mental risk in this project.
- You may detach this sheet and retain it if you wish.

*This sheet provides data mandated by, under authority of, and in conformity with:

- 10-USC-Sec. 4503
- The Privacy Act of 1974 (5 U.S.C. 552a)
- Directive AR 70-1
- Appendix A to ARI Reg. 70-25 (1 Aug 79)
- Code of Federal Regulations, Title 45, Sec. 46.6(B)

(Form approved ARI 2 Aug 1982)

ORGANIZATIONAL MAINTENANCE EVALUATION QUESTIONNAIRE

PURPOSE

This questionnaire is for key maintenance personnel in armor and mech. infantry units at Fort Carson. Your answers will help us improve organizational maintenance. The questionnaire is short and should take you about 15 minutes to complete.

You already know that effective organizational maintenance is essential to the success of unit missions. Maintenance experts believe that organizational maintenance is the foundation of the Army maintenance pyramid.

The Army has contracted with Anacapa Sciences to investigate maintenance problems from several different angles. Anacapa Sciences has developed a organizational maintenance performance system which is being tested by selected units.

We have spent many hours interviewing maintenance leaders such as yourself. We are familiar with organizational maintenance problems and have developed ideas for solving some of them. But, before we can report on the effect of these ideas on maintenance, we need some baseline and user data on maintenance effectiveness in your unit.

To be completed by interviewer.

1. Name _____
2. Unit _____
3. Rank _____
4. Mechanic MOS (check box below)

- ☐ 31 V
- ☐ 45 N/T
- ☐ 63 B/S
- ☐ 63 N/T

MAINTENANCE MECHANICS EVALUATION QUESTIONNAIRE

INSTRUCTIONS

- Read this set of statements and check one box from the five choices opposite each question.
- Note that questions apply only to conditions in this unit--today!

1. Are jobs assigned according to records of a mechanic's experience?	Never <input type="checkbox"/>	Seldom <input type="checkbox"/>	Some- times <input type="checkbox"/>	Frequently <input type="checkbox"/>	Always <input type="checkbox"/>
2. Is structured OJT used to improve skills of all mechanics?	Never <input type="checkbox"/>	Seldom <input type="checkbox"/>	Some- times <input type="checkbox"/>	Frequently <input type="checkbox"/>	Always <input type="checkbox"/>
3. Are repairs done to a set of standards?	Never <input type="checkbox"/>	Seldom <input type="checkbox"/>	Some- times <input type="checkbox"/>	Frequently <input type="checkbox"/>	Always <input type="checkbox"/>
4. Are repeated tasks on a piece of equipment traced back to the mechanic who did the repair?	Never <input type="checkbox"/>	Seldom <input type="checkbox"/>	Some- times <input type="checkbox"/>	Frequently <input type="checkbox"/>	Always <input type="checkbox"/>
5. Are new ALT graduates assigned to a structured OJT program?	Never <input type="checkbox"/>	Seldom <input type="checkbox"/>	Some- times <input type="checkbox"/>	Frequently <input type="checkbox"/>	Always <input type="checkbox"/>
6. Do mechanics participate in maintenance problem diagnosis?	Never <input type="checkbox"/>	Seldom <input type="checkbox"/>	Some- times <input type="checkbox"/>	Frequently <input type="checkbox"/>	Always <input type="checkbox"/>
7. Are mechanics told how they're progressing during OJT?	Never <input type="checkbox"/>	Seldom <input type="checkbox"/>	Some- times <input type="checkbox"/>	Frequently <input type="checkbox"/>	Always <input type="checkbox"/>
8. Is skill achievement publicized through award of a certificate?	Never <input type="checkbox"/>	Seldom <input type="checkbox"/>	Some- times <input type="checkbox"/>	Frequently <input type="checkbox"/>	Always <input type="checkbox"/>
9. Are special maintenance record summaries used to pinpoint problem areas during maintenance discussions?	Never <input type="checkbox"/>	Seldom <input type="checkbox"/>	Some- times <input type="checkbox"/>	Frequently <input type="checkbox"/>	Always <input type="checkbox"/>
10. Can mechanics compare the number of times individuals have done a job against other mechanics?	Never <input type="checkbox"/>	Seldom <input type="checkbox"/>	Some- times <input type="checkbox"/>	Frequently <input type="checkbox"/>	Always <input type="checkbox"/>

STOP!

APPENDIX C

EXAMPLES OF RESPONSES FROM SUPERVISORS/MECHANICS EVALUATION QUESTIONNAIRES

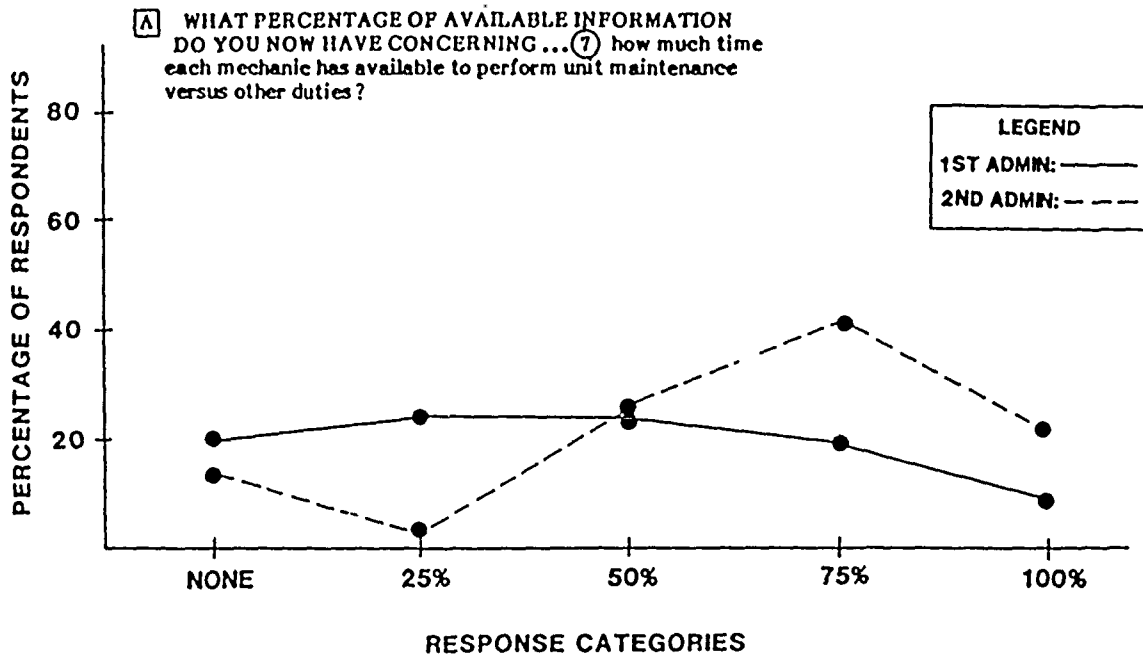


Figure C1. Supervisors' responses for two administrations of evaluation questionnaire-- MPS(O) Bn 1 (Question A7).

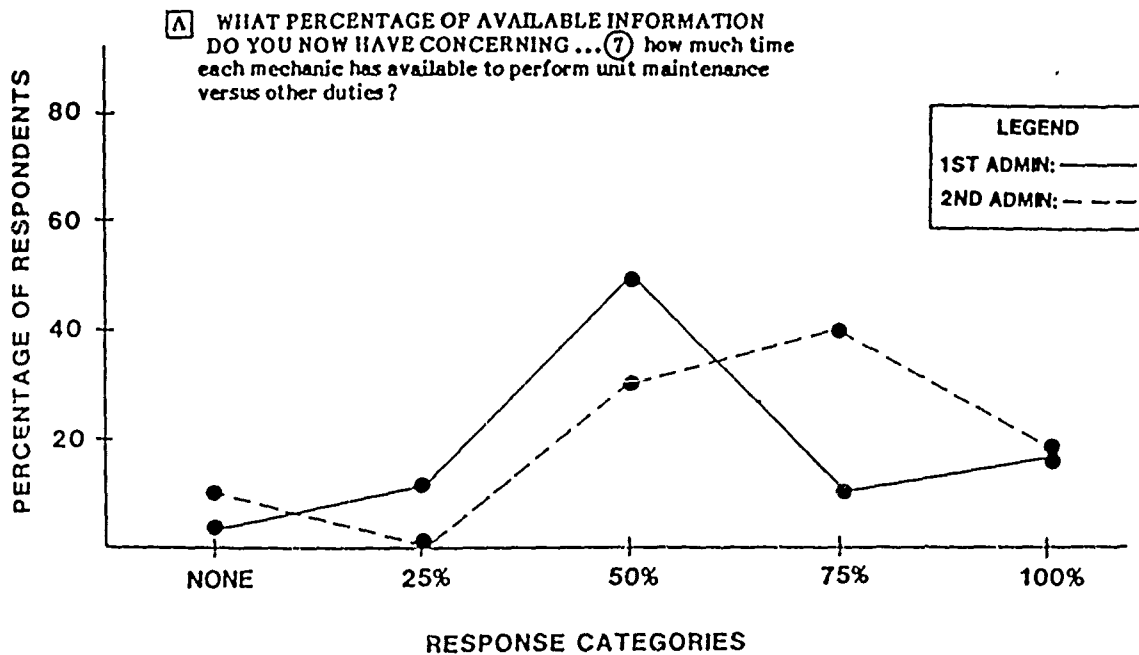


Figure C2. Supervisors' responses for two administrations of evaluation questionnaire-- MPS(O) Bn 2 (Question A7).

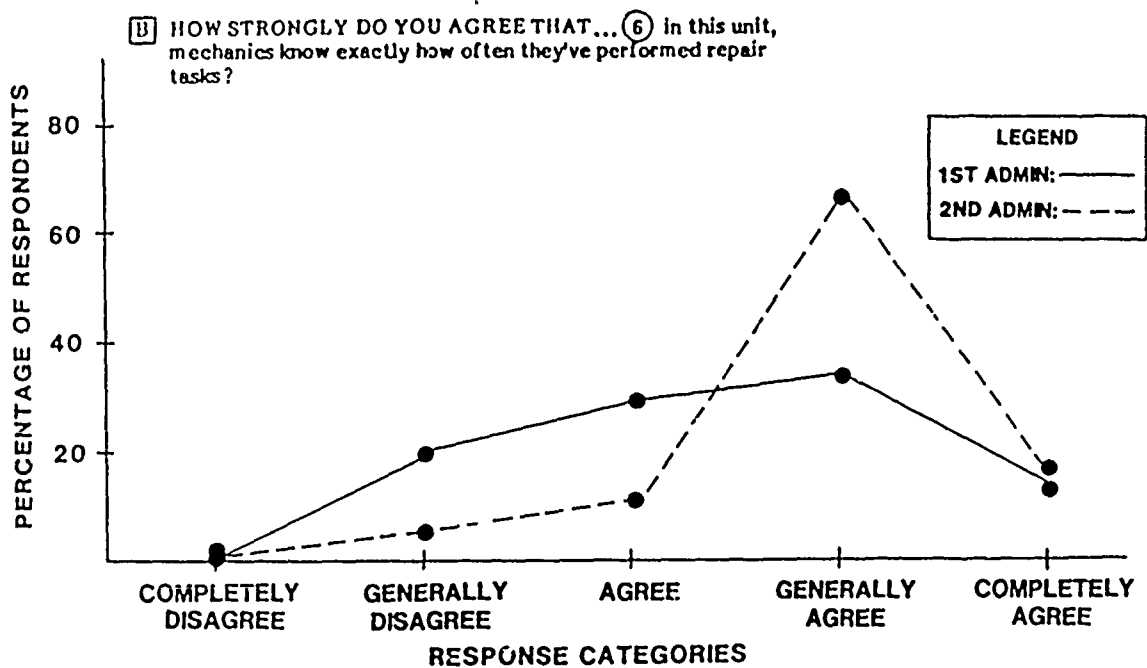


Figure C3. Supervisors' responses for two administrations of evaluation questionnaire--MPS(O) Bn 1 (Question B6).

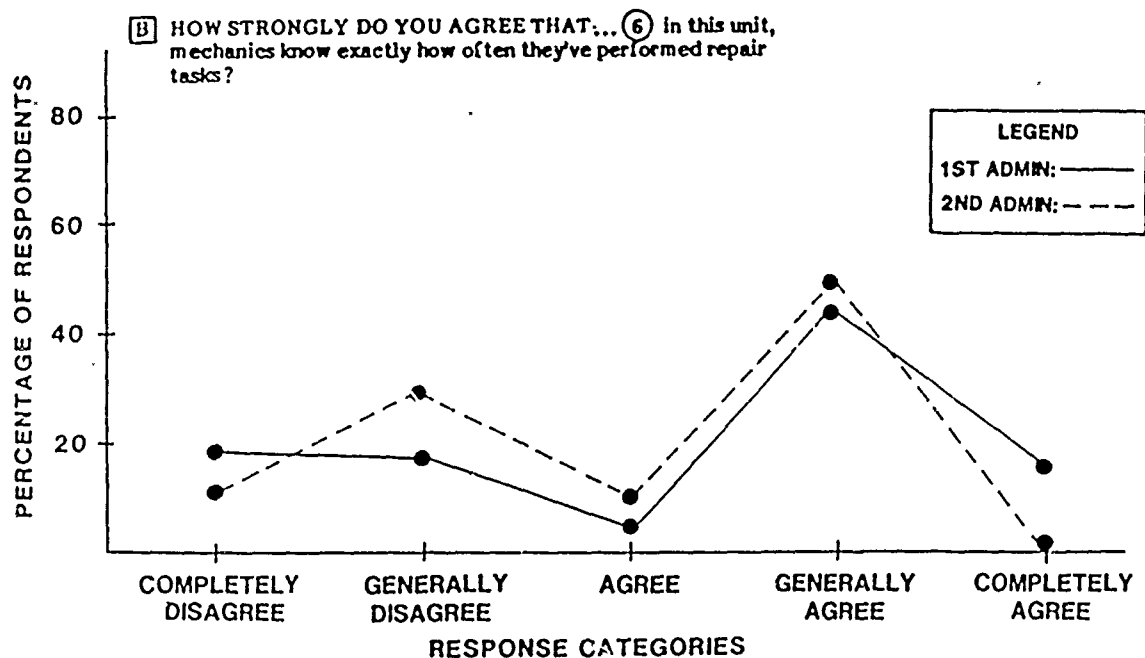


Figure C4. Supervisors' responses for two administrations of evaluation questionnaire--MPS(O) Bn 2 (Question B6).

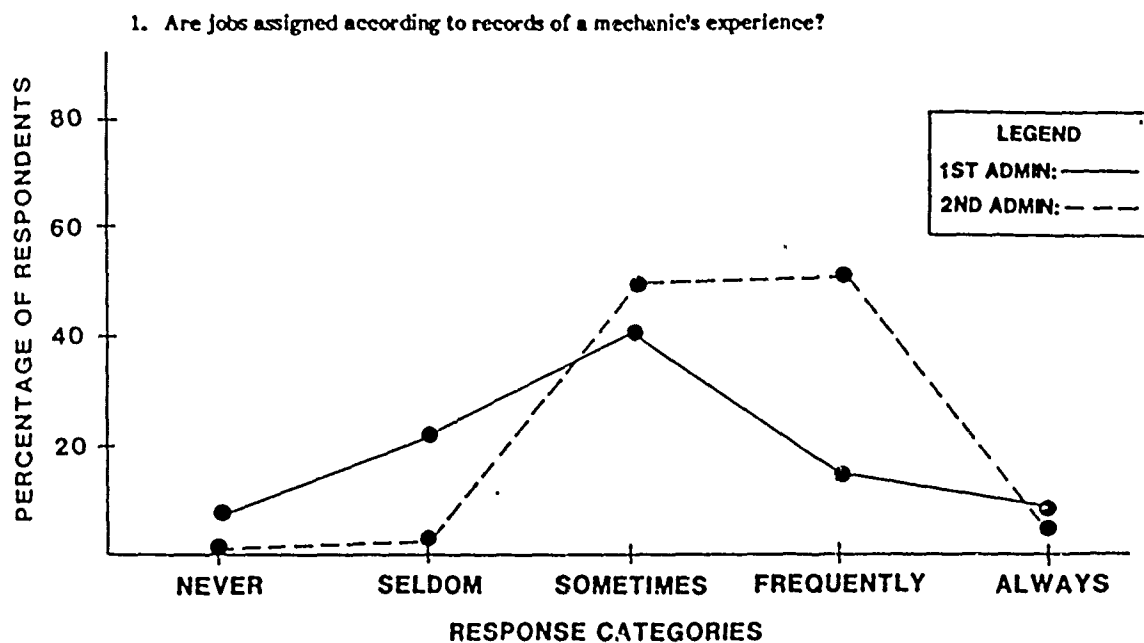


Figure C5. Mechanics' responses for two administrations of evaluation questionnaire--MPS(O) Bn 1 (Question 1).

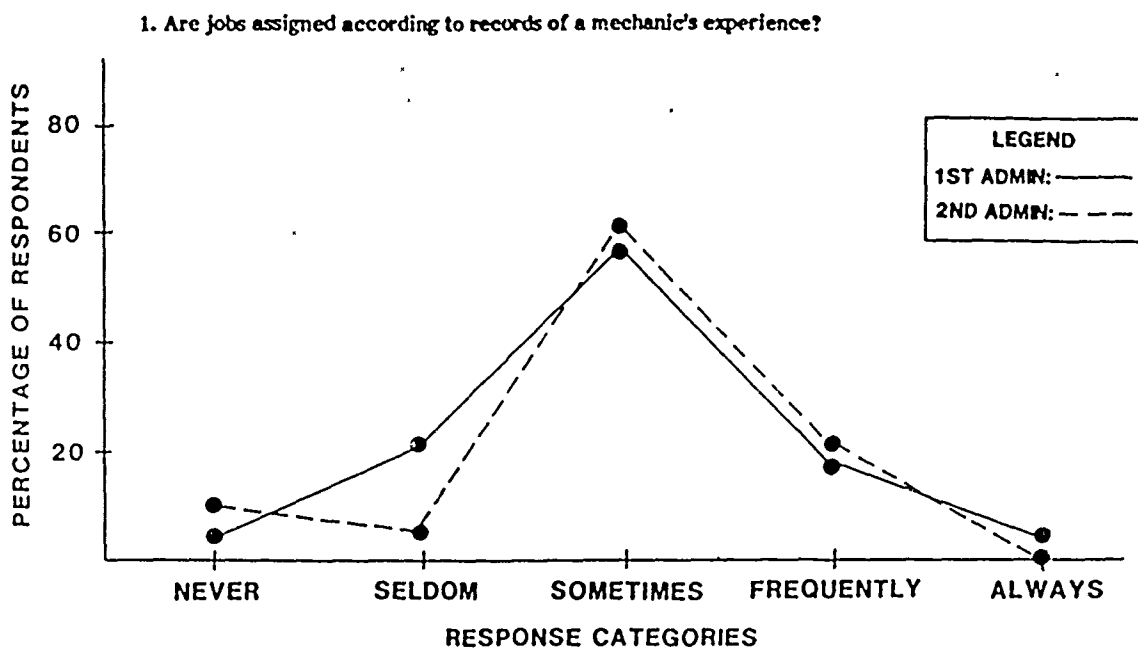


Figure C6. Mechanics' responses for two administrations of evaluation questionnaire--MPS(O) Bn 2 (Question 1).

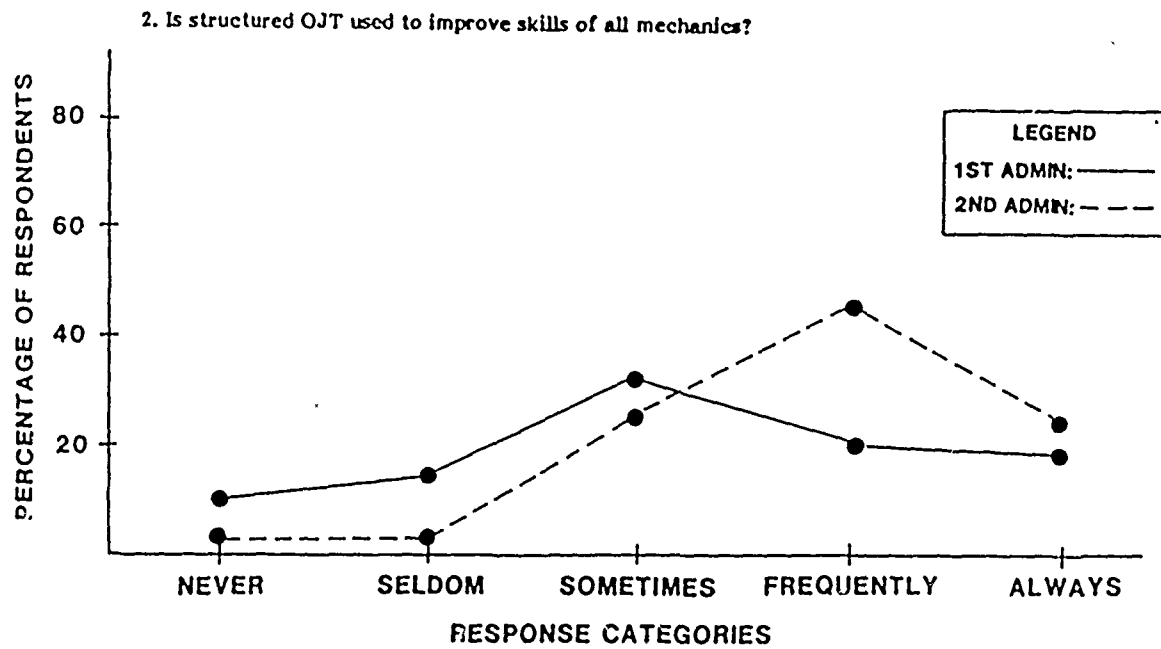


Figure C7. Mechanics' responses for two administrations of evaluation questionnaire--MPS(O) Bn 1 (Question 2).

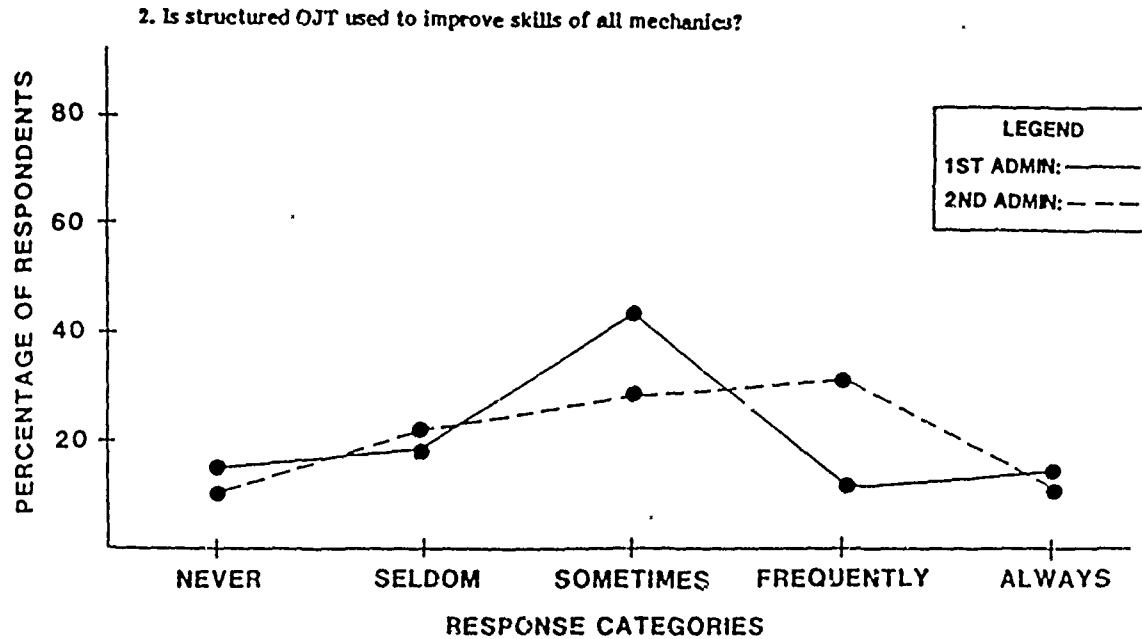


Figure C8. Mechanics' responses for two administrations of evaluation questionnaire--MPS(O) Bn 2 (Question 2).